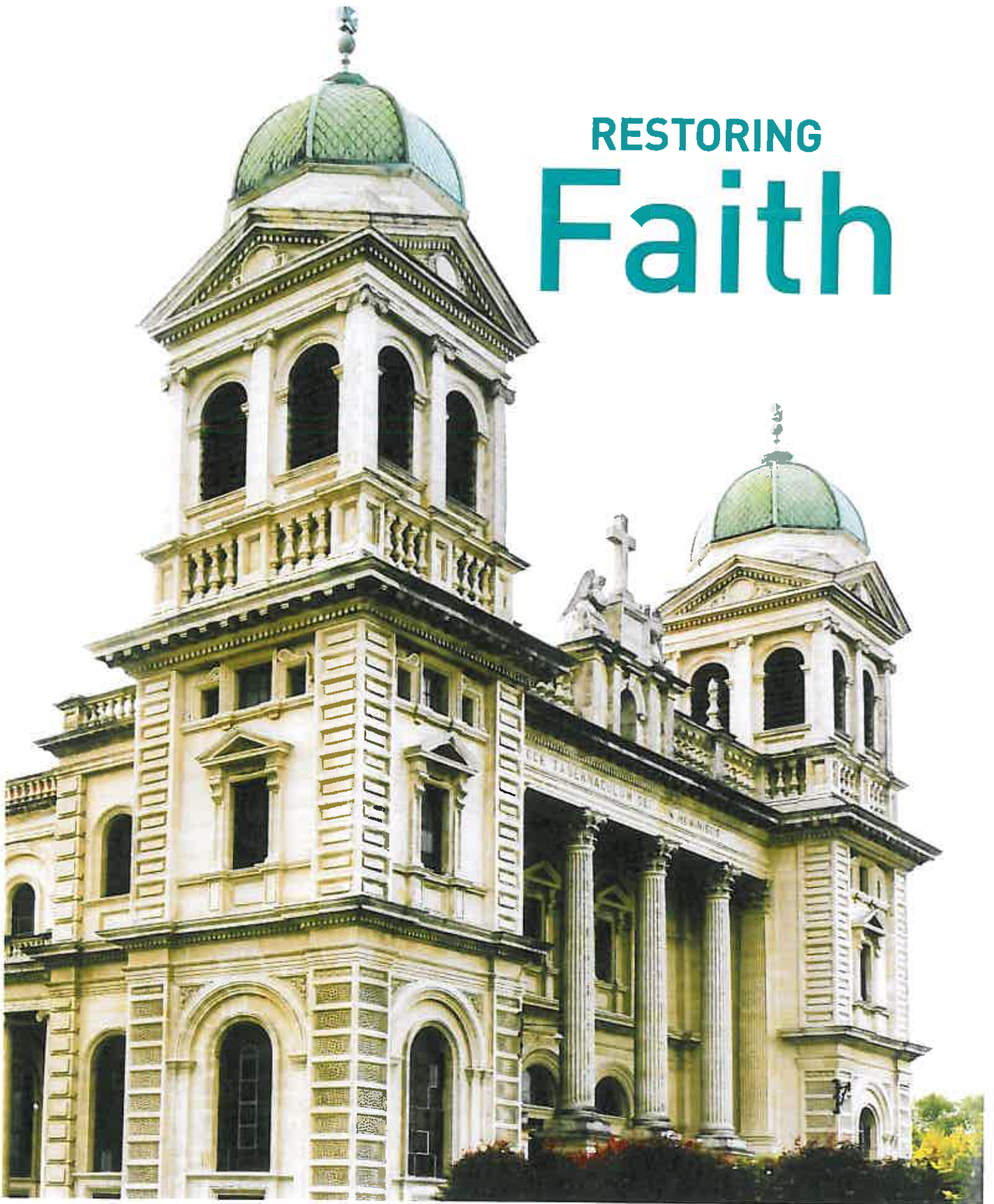


RESTORING Faith



The earthquake which struck Christchurch on 22 February of this year has left many scars on the city's precious heritage buildings. Still standing amongst the devastation, however, is one of the city's most important but less widely-known heritage buildings, the Cathedral of the Blessed Sacrament – also known as the Christchurch Basilica. The basilica is a stunning architectural masterpiece in Italianate Renaissance style, as well as an important focal point for the Australasian Catholic community. And although it has suffered considerable structural damage to the two towers which flank the entry portico and the main dome towards the rear, there is hope an ingenious plan to temporarily remove the basilica's main dome may eventually enable large sections of the building to be saved.

Christchurch has suffered more than 5,000 earthquakes since the magnitude 7.1 earthquake struck the city on 4 September last year. However, although the September event had the largest magnitude of these shakes, it is the quake of 22 February which has caused the most severe damage in the city and loss of life. This is because the February earthquake was located closer to both the surface and the city than the one in September. In addition, an aftershock on Boxing Day also caused considerable damage within the central city area.

A heritage icon

Listed as a Category 1 building on the New Zealand Historic Places Trust Register and Group 1 on the Christchurch City Council plan, the basilica is the latest in a series of buildings built by the Catholic Church on this site. The first – a small wooden chapel – was constructed in 1860, only to be replaced by a larger wooden structure in 1864. This church was expanded over the years to become the pro-cathedral of the newly established Diocese of Christchurch in 1887, but was removed in 1901 so work on the basilica could begin. The basilica itself was officially opened in 1905.

The basilica is constructed of internal and external layers of Oamaru limestone with no fines concrete fill in between. Fifty men were employed to build it, and it took in excess of 3,400 cubic metres of stone, 110 cubic metres of concrete and 90 tonnes of steel to construct. Twin towers were erected to flank the front entry portico of the building: the north tower contains four bells with a combined weight of 3.5 tonnes, while a clock tower was planned for the southern one, although this didn't eventuate.

The main dome is one of the basilica's most important design features. Francis Petre, the architect, intentionally located it directly above the sanctuary of the cathedral rather than over the crossing of the church as is normally the case.

The 2010 damage and assessment work

Jamie Lester, Structural Engineer with Opus International Consultants in Christchurch, Andrew Brown, Senior Structural Engineer, and Aucklander Carole-Lynne Kerrigan, Built Heritage Specialist, first became involved with the basilica after the September earthquake.

"After September there was only minor damage to the basilica," Mr Lester says. "This was mainly related to falling hazards, and



Some of the work to protect and to completely restore the basilica is already well under way. Image courtesy of Opus International Consultants

some stability issues related to parts of the two towers at the front. The Diocese and insurer asked us in to assess and record the damage in order to identify appropriate repair solutions."

The building was red placarded (meaning it was unsafe) until the assessment work could be completed, but subsequent events have meant only engineers have been able to enter the building since September.

"We had completed the outside assessment with the cranes by the end of last year and had programmed to do the inside after Christmas. But then the Boxing Day [aftershock] happened, the towers wobbled, so we had to stabilise the towers before we could get inside," Ms Kerrigan says.

The Boxing Day aftershock caused significantly more damage, mainly to the two towers – including a big crack in both of them at the main roof level. In addition, the top section of one of the towers moved horizontally about 25 millimetres.

"At that point we realised we needed to secure those two towers to prevent them from moving any further," Mr Lester says. "Our main aim was to stabilise the building so that we can first of all record what the building looks like in terms of heritage features. At the same time, we needed to identify what structural damage had occurred, with a view to repairing and strengthening the building permanently."

The February quake

Large steel frames were designed following the Christmas break to temporarily stabilise the twin towers until a permanent stabilisation solution could be implemented. These frames had already been manufactured by February, and were due to be installed on the 24th once site preparations – including an unexpected archaeological investigation – were completed. The foundations had been excavated to provide the uplift for the structure, and the concrete was ready to pour.

"In digging the trenches for the steel at the front of the cathedral we discovered features possibly relating to earlier church structures," Ms Kerrigan says. "So we were carrying out an archaeological excavation alongside the stabilisation, and that's when the February quake happened."

The tops of both front towers came down in that event, but fortunately no one was injured, even though there were four people working directly under the north tower at the time.

"I just ran," Ms Kerrigan says. "We all managed to shelter behind the shipping containers that had been put alongside the road, and watched the towers explode. It was terrifying."

On a positive note, the steel frames have since been modified and put to good use as temporary stabilisation for a badly damaged wall at the Old Municipal Chambers building in the central business district.

The engineers were also part-way through scoping out an option for the insurers to install bracing around the rear of the basilica to prevent further damage from any future aftershocks. There had been some minor additional damage to this section of the building from the Boxing Day aftershock, but the main goal was to reduce the amount of damage that would need to be dealt with in the long run. The notion that worse damage was yet to come was not anticipated.

"It wasn't so much that we thought this was going to fall off in a hurry," Mr Lester says. "We were thinking that if we put some bracing in now, we would minimise the repairs to manage from an insurer's perspective. We were basically trying to brace and support what was already damaged until we could undertake repairs."

In the September earthquake, there was no damage to the stained glass and only minor damage to the mosaic, although a truss did fall through from the dome. But Ms Kerrigan noted that after Boxing Day there seemed to be subsidence in the area of the sanctuary. "We also started noticing that, after Boxing Day

Looking through the collapsed roof into the interior of the cathedral beneath the main dome. Image courtesy of Opus International Consultants



and in all the small subsequent aftershocks, the stained glass was cracking and small pieces were falling out. We don't know what has happened internally after February, although we can see from the outside that a lot of the stained glass has been lost."

The February event caused significant damage to the rear of the basilica sacristy area. This was related partly to the direction of the earthquake, and is also a result of the dome's heavy weight and height. The entire dome section weighs something around 300 tonnes, and is supported on large arches coming down onto four large columns. Shear failure of the dome structure has caused a large hole to open up in the drum of the dome on one side, and the first floor roof has partially collapsed.

"There seems to be something odd going on with the rafters in the dome because you can see the copper on the main dome has wrinkled," Mr Brown says. "There has obviously been some sort of twisting action, which has forced the dome to try to spiral down on itself. There are also cracks from where the dome meets the roof, tracking all the way down to the bottom rear corner of the building because of the weight and the ground motion. The whole rear section has cracked and moved."

The deconstruction plan

The main focus now is to stabilise the rear of the basilica by removing the weight of the large dome, which is further weakening the back wall of the building with every aftershock. This will also remove the falling hazard the dome currently presents. In addition, the north tower needs to be secured either by removing damaged parts or by shoring it up.

"We're going to deconstruct the main dome using a 400-tonne crane – one of the largest in the country," Mr Lester says. "The plan is to first of all take the roof of the dome off, which is basically timber trusses with copper over the top. Then we're going to work our way down taking it off in pieces."

Some of the lifts will be very heavy, with the section between the windows and the base of the dome alone estimated to weigh around 80 tonnes. The plan involves rigging up a steel lifting frame to fix to the top section of the roof. The fixings will then be broken out and the copper dome removed. The next section of stone has a strengthening concrete ring beam fixed to it, and will be taken off in one piece – a lift of around 50 tonnes. There's also a second concrete ring beam around the bottom of the dome's clerestory windows.

Mr Lester says the plan is to take the piers between the windows down piece by piece. Every second one has a concrete pilaster on the inside from previous strengthening. Then the rest of the dome's drum will be deconstructed in small elements.

It is expected to take a few weeks to remove the dome to first floor roof level, followed by a further couple of months before the building is fully weatherproofed and secured. It won't be a quick process – it's not like demolition. The team has to record features as they go, and take care with the stone as it is removed so that if rebuilding is an option they can either reuse it or copy the details.

There is, nevertheless, a degree of urgency to the project with the aftershocks being the way they are. "The building is basically

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- Archaeological surveys
- Archaeological excavations
- Predictive risk modelling
- Mitigation strategies
- Project monitoring
- RMA and planning advice
- Heritage conservation assessments
- Conservation plans



We're going to deconstruct the main dome using a 400-tonne crane – one of the largest in the country

Oamaru limestone on the outside and inside, which forms a sort of permanent formwork that is keyed into the concrete in the middle," Mr Lester says. "But it's quite a weak no fines concrete, with no reinforcing. There is some reinforcing in the building, mainly in the existing floors, but it's quite light."

The team undertook two concrete core tests while assessing some of the early damage. In one the concrete just crumbled, while the other one remained intact – and that was just within a space of about 300 millimetres.

The foundations are also concrete, and have been stepped out beyond the walls to spread the load. It looks as though there hasn't been much in the way of liquefaction around the site, so the engineers are hopeful that the building platform will be relatively level and stable inside.



Images: In the team: Duayne Vercoe Crane Driver/Dognan and Murray Flett Site Manager, complete preparations for removing the stonemason's dome. Image courtesy of Goud International Consultants

Picking up the pieces

"I've spent lots of time over the past fortnight picking up every piece of copper that I can from the debris that has fallen from the south tower – including nails," Ms Kerrigan says. "The cupolas were made out of eight sections, and there are two sections of the southern tower's dome that have remained more or less intact. So I've numbered every tile, unclipped them and put them in bags so that if we decide to reconstruct, it will be easier.

"I've also retained intact the least damaged section of the timber roofing members and sarking, so we've got that at least as a sample. And we've done sketches. The aim is to collect as much as we can that we can potentially reuse, or that is important in terms of detailing. So far, with only a little bit of the timber and all the copper we've nearly filled one [shipping] container.

"Now we've got to sift through the stone, because a lot can potentially be pinned together and put back up. If that's not feasible, we can carve new pieces using broken sections as samples. With the forms already there, half the job's done."

Despite the tragedy, the damage has provided an intriguing opportunity to see how the building was originally constructed. It also provides hope that a way will be found to painstakingly piece this precious building back together again.

"The two tower cupolas were built like boats," Ms Kerrigan says. "They've built the underlying timber structure, and then clad it with kauri sarking boards. These boards have retained their curved shape and provide support for a waterproofing membrane over which copper tiles were fixed with copper nails. The gutters, downpipes and flashings are all copper."

Ms Kerrigan, Mr Lester and Mr Brown agree the project is interesting and challenging.

"I'm definitely enjoying it although the big challenge that still lies ahead is determining how much of the building can be saved, and then how it can be repaired. It has also been interesting working on a building that's very much in the public focus," Mr Lester says, adding that this project is very different from the type of work structural engineers usually do. "With a new building you tend to work out a structural system, analyse it, and then design the details. As new buildings are not designed using unreinforced stone, it is challenging to work out how to introduce strengthening with desirable mechanisms resulting in only minimal impact on the building fabric.

"Stone is a brittle material, certainly compared to something like steel, so as soon as you get any movement it cracks or slides. We will have to work out how much movement is going to be too much under a design earthquake."

"The scale of this project in many ways is just a bigger scale of what we do every day," Ms Kerrigan says. "What I am enjoying is working alongside a group of people – including the crane driver, site manager, stonemason and engineers – and talking together about likely solutions. This includes talking with the people at the Catholic Diocese, who have all been very helpful and supportive of the work we are doing. And because we're doing the work in very small steps, and we're talking to each other, it's not overwhelming. It's actually very rewarding to be part of something so important to the people of Christchurch."

WRITER Karen Wrigglesworth