INDEPENDENT ASSESSMENT ON EARTHQUAKE PERFORMANCE OF

The Methodist Church Building At 309 Durham Street North

FOR
Royal Commission of Inquiry into building failure caused by the Canterbury Earthquakes

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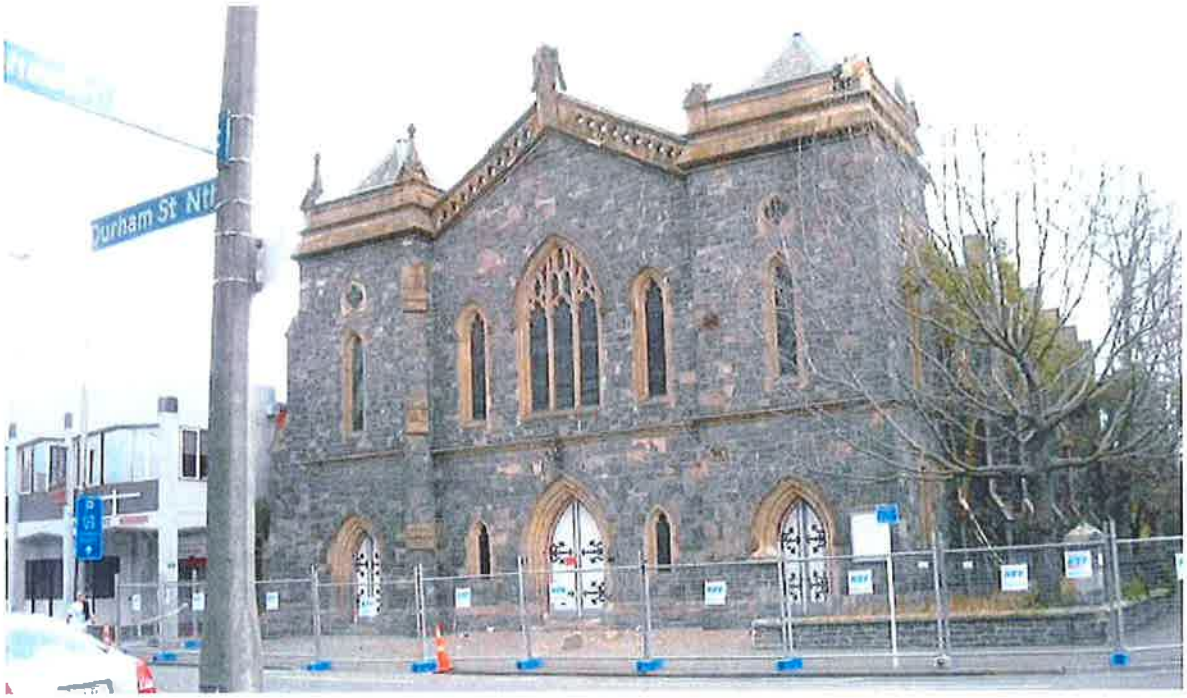

Introduction

This report has been commissioned by the Royal Commission of Inquiry into building failure caused by the Canterbury Earthquakes to review aspects of the performance of the building at 309 Durham Street North, Christchurch, during the Canterbury earthquake sequence.

The report is based on documentation provided by the Royal Commission of Inquiry into building failure caused by the Canterbury Earthquakes. No inspection of the building was possible prior to demolition.

Location of Building

The Methodist Church building at 309 Durham Street North was located on the southwest corner of the intersection of Durham Street and Chester Street, with Durham Street to the east and Chester Street to the north.

The location of the building is shown on an aerial photo of Christchurch included in Appendix 1, together with the direction from the epicentre of the main earthquakes.

Geotechnical Site Assessment

Geotech Consulting were engaged in 2009 to carry out a limited investigation for the site. In their investigation they found that the ground beneath the church was prone to liquefaction. The report concludes that there was a high risk of seismic liquefaction at the site, with an estimated settlement under ultimate limit state conditions in the order of 400 – 450mm. The affected soils were found to depths of up to 18 metres below the church.

Description of Building

The original building was built in 1864 and consisted of three main areas.

A description of the building is included in the Structex Metro Ltd report of 4th October 2010;

> *The complex consists of three main areas, the main Church auditorium, the annex located at the western end of the auditorium and the Hall located in the south west corner of the site.*
>
> *The buildings are generally constructed with stone walls, consisting of a natural stone exterior, a plaster brick and stone interior and a combination of rubble and stone fill to the cavity.*
>
> *The slate roof is likely to be supported on battens with timber sarking on purlins and main supporting exposed timber trusses. A ceiling is constructed with lathe and plaster. The ground floor is timber and is likely to consist of timber flooring boards on joists supported on timber bearers on concrete or timber piles.*

A gallery floor has been constructed in the auditorium which extends around the perimeter of this area. Access to the gallery is by two stairs at the front of the church facing Durham Street which incorporates two stone towers.

The Church was oriented east-west on the northern half of the site. The Church Hall was oriented north-south, and was perpendicular to the Church to create a "right angle".

There was another two level building, the Aldersgate building, located to the southeast of the site, located to the east of the Hall. This was a separate building, of modern construction, and was located at 307 Durham Street.

The church walls were constructed with a stone masonry facing and rubble infill.

Compliance

A review of the Christchurch City Council records indicates that the building complied with the requirements of the Building Act 1991 due to the building pre existing the Building Act and no alterations or change of use occurring since the introduction of the Building Act 1991.

Christchurch City Council Policy on Earthquake Prone Buildings

We understand that following the introduction of provisions in the Municipal Corporations Act for territorial authorities to require building owners to strengthen or demolish unreinforced masonry buildings, the Christchurch City Council applied for and was granted powers under the Section 301A of the Municipal Corporations Act. The Christchurch City Council adopted a passive approach to the upgrading of earthquake risk buildings.

The building was subject to a Seismic Risk Building Survey on the 17th December, 1992 by the Christchurch City Council. The numerical rating for the building was 13 which was a B Classification.

The Christchurch City Council survey required B Classification buildings to be remediated within 2 years.

The Christchurch City Council's first policy in respect of earthquake-prone, dangerous and in-sanitary buildings was introduced in 2006.

This policy was reviewed in early 2010, and the Methodist Church provided a submission to the Christchurch City Council.

The Christchurch City Council considered the building to be an earthquake prone building prior to the 4th September, 2010 earthquake.

Strength Assessment of Building

In December 2008 RD Sullivan & Associates Ltd undertook a report on the condition of the roof structure of the first floor music room. They recommended that the timber trusses be tied to the stone walls with galvanised steel threaded rods grouted into the stone walls and provided details of the strengthening. RD Sullivan & Associates Ltd assessed that this work would reduce the risk of a roof collapse in an earthquake, but it would not add to the overall strength of the church and annex buildings in an earthquake.

The recommended work was not undertaken.

In September 2009 RD Sullivan & Associates Ltd undertook a condition report. They concluded, that in their opinion, all three parts of the church, annex and hall would collapse if subjected to a moderate earthquake, defined as a third horizontal acceleration required for design of a new building built of similar materials on the site.

As the building had not had any recent alterations or change of use, no strengthening work had been carried out by the church.

Events Subsequent to 4th September 2010 Earthquake

The building was damaged in the 4th September, 2010 earthquake. The building damage was described to consist of;

- the east end of the church being close to collapse with extensive cracking
- cracking to the north and south walls between the buttresses
- west wall to church (adjacent to organ) have some cracks but overall is in fair condition
- west side of the annex and hall has cracked stonework and has displaced out from the roof and floor structure approximately 80mm.

The building was red placarded as part of the Civil Defence Rapid Assessment procedure after the 4th September, 2011 earthquake.

The Christchurch City Council considered the building to be an earthquake prone building prior to the 4th September, 2010 earthquake.

On the 17th of September, 2010, the Christchurch City Council considered the building to be a dangerous building under the Earthquake Recovery Dangerous Buildings Programme.

RD Sullivan & Associates Ltd provided an initial damage report on 15th September, 2010 recommending temporary propping be designed and installed and recommending that the pipe organ be removed whilst work on the church was undertaken.

On 23rd September, 2010 RD Sullivan & Associates Ltd approved the work to remove the loose dislodged portion of the east gable to Durham Street, which was undertaken in conjunction with Arrow International Ltd. On 28th September, 2010 Christchurch City Council provided approval to remove loose stones and proceed with temporary steel propping.

RD Sullivan & Associates Ltd had forwarded Arrow International Ltd a set of drawings on 1st October, 2010 for the temporary support to the external western wall of the church and hall, the north-east corner and the eastern gable of the church building.

RD Sullivan & Associates Ltd were dismissed from the project on 4th October, 2010. The extent of the dismissal is unclear, as the email from the Methodist Church suggests that RD Sullivan was to complete their engagement for this building. However, it is clear that Structex Metro Ltd undertook the role of advising the Methodist Church and Arrow International Limited after this date.

An initial structural report by Structex Metro Ltd on the building was issued on 4th October, 2010.

On 5th November, 2010 the installation of the steel temporary propping detailed by RD Sullivan & Associates Ltd to the Durham Street frontage and Chester Street corner was completed. It appears that the propping to the west wall of the annex and hall was not installed.

Structex Metro Ltd advised on the 10th November, 2010 that the Aldersgate atrium itself was structurally sound, and confirmed safe occupancy to the Aldersgate building provided that the entry atrium area was protected by a scaffold. It suggests re-location of the main entry to the Aldersgate building.

The building collapsed in the 22nd February, 2011 earthquake. A red placard was placed on the collapsed building on the 25th February, 2011.

On 22nd March, 2011 a Rapid Assessment - Level 2 was undertaken and the existing Red Level 1 placard was superseded with a Yellow 1 placard indicating restricted use. This was for the Aldersgate building, and is based primarily on the Church being substantially removed at this stage.

Temporary Propping for Organ Removal

Arrow International Ltd forwarded details of the temporary propping to the Christchurch City Council on 11th October, 2010 for the Durham Street Methodist Church. The temporary propping was designed by RD Sullivan & Associates Ltd and the design adopted a risk factor of 0.5.

Structex Metro Ltd reviewed the propping details by RD Sullivan & Associates Ltd and reported on 21st October, 2010, however, Structex Metro Ltd did not review the calculations. Structex Metro Ltd were aware that the intention of the propping was to provide public safety and avoid collapse of the towers onto the footpath. They commented that the works were of a robust nature to provide temporary medium term support to the east wall and the north east tower. They noted that temporary propping in addition to the tower is not considered to be necessary to allow removal of the organ, piano and music library. They noted;

> *Based on our inspection and report dated 4 October, 2010, we believe that the main Church auditorium has not had significant structural damage and is therefore unlikely to collapse as a result of significant aftershocks. Temporary propping in addition to the tower is not considered to be necessary to allow removal of the organ, piano and music library. We recommend that building occupancy be minimised to assist in reducing risks to persons carrying out removal work.*

RD Sullivan & Associates Ltd noted that on 4th October, 2010, the Methodist Church advised that their services were no longer required. At that date, they had mostly completed a temporary propping design for the eastern façade of the church and the west walls of the annex and hall. They had not carried out the propping designs of the north and south walls as recommended in their initial report of 15th September, 2010. They were not engaged during the erection of the temporary propping and did not carry out any construction observation.

As noted previously, it appears that the propping to the west wall of the annex and hall designed by RD Sullivan & Associates Ltd was not installed.

Building Strength Assessment

The Structex Metro Ltd report of 17th February, 2011 assessed the auditorium to the main church to have a lateral load capacity of 10% of current code. This assessment of strength was based on the building in its pre-earthquake condition with no cracks.

The Structex Metro Ltd report of 17th February, 2011 on the church hall building indicates that the building was assessed to have a longitudinal strength of 16% of current code and a transverse strength of 17% of current code. This assessment of strength was based on the building in its pre-earthquake condition with no cracks.

Both reports assessed the existing buildings to have had their structural capacity reduced by the earthquake damage from the 4th September, 2010 earthquake.

The Structex Metro Ltd letter of 16th February, 2011 stated;

> *We understand that the building, as well as its contents are of significant historical value. It is therefore necessary that additional temporary bracing be installed to the north wall of the Auditorium, as well as the west wall of the Hall to provide longer term protection to the building and its contents in the event of significant on-going aftershocks.*

Consent for the Organ Removal

Structex Metro Limited reported on 1st February, 2011 on an alternative safe egress route for removal of the pipe organ and other chattels, and advised they had reviewed providing access through the north door of the annex. This option required a protective scaffold to be erected over this door to protect the entry from collapse of the loose stone work above.

The Chester Street entry doors of the church had the loose stones above the entry removed on 8th February, 2011 and the scaffold was erected on 10th February, 2011.

On 10th February, 2011 there was also a meeting with the Christchurch City Council, Methodist Church and an Arrow International Ltd representative in the church to discuss the removal of the pipe organ and chattels.

On 11th February, 2011, Arrow International Ltd wrote to the Christchurch City Council providing a proposal relating to the removal of the organ. Arrow International Ltd undertook to lodge a resource consent to cover the stone removal necessary to make the building safe for the temporary propping, the stained glass window removal, the organ removal, and removal of fixed and loose furniture and fittings by 18th February, 2011.

The proposal included an outline and methodology for the organ removal. The methodology included for a scaffold platform to be erected directly in front of the organ above the height of the choir stalls, approximately 3 metres above the auditorium floor level. It also identified the most efficient safe passage out of the building to be through the Aldersgate atrium. It appears that the scaffold platform was a working platform and not a means of protection for the workers should there be any instability in the existing walls of the building.

The safe passage through the Aldersgate atrium was not consistent with the Structex Metro Limited 1st February, 2011 report, however, it is as per their earlier advice.

The programme was for the work to be undertaken between 14th February, 2011 and 25th February, 2011 with the scaffold to be removed after that date.

There were various emails from the Christchurch City Council, internally on the 14th February 2011, regarding Christchurch City Council's concern that there was work being done to the building, which was a Group 1, Category 1 heritage building, without proper consents. There was no record of discussions regarding the life safety elements of the operation, however, they were concerned regarding the risk to the interior fittings of the church in undertaking the organ removal operation.

On 15th February, 2011 there was an email from the Christchurch City Council to Arrow International Ltd providing approval and conditions for the organ removal. Part of the conditions was a requirement that no scaffolding should be erected within the building in a manner which required drilling or bolting to the interior of the protected building. There is no record whether the consent applications that were required to be provided by the 18th February 2011 by Arrow International Ltd to the Christchurch City Council were completed.

We understand that the building was still red placarded and was considered a dangerous building by the Christchurch City Council at the time of the approval for the removal of the organ.

Structural Failure

In the 4th September, 2010 earthquake, the building damage included cracking to the stone side walls and gables. The top section of the east side wall collapsed. The west wall was displaced out by about 80mm. No ground liquefaction or gross settlement of the building was observed.

We understand that the building collapsed in the earthquake of 22nd February, 2011 and three men were tragically killed in the building when they were part of a group of eight workmen involved undertaking the removal of the organ from the building.

We are not aware of the location within the building that the deceased men were found, and so cannot comment on the specific wall collapse in relation to those walls previously noted as being damaged and/ or temporarily propped.

We would note that the temporary propping was ineffective at preventing collapse of the walls supported. Based on GNS Science records of measurements of accelerations in the Christchurch CBD during the 22nd February 2011 earthquake, the building is likely to have been subjected to accelerations of 0.9g. The propping was design with a risk factor of 0.5, effectively half of current code, and so was not designed for the accelerations experienced on the 22nd February, 2011.

Issues Arising from Review

Status of building

The building was considered to be earthquake prone by the Christchurch City Council, and the building owner was aware of this status prior to the 4th February, 2010 earthquake.

On 11th August 2011 the Methodist Church of New Zealand had wrote to the Royal Commission noting that for several years prior to the earthquakes, the church sought reports from RD Sullivan & Associates Ltd on the structural strength and upgrading options for the church. A decision on any strengthening work was held pending clarification of the Christchurch City Council's policy on upgrading earthquake prone buildings.

The building had not had any strengthening undertaken on the building, other than the temporary propping after the 4th September, 2010 earthquake, of which aspects that were designed were not installed, and the design for other walls intended to be propped was not completed.

The status of the building as an earthquake prone building did not appear to be a factor in the Christchurch City Council's consideration of the consent application for removal of the organ. The consent approval appears only to have considered the heritage issues.

Was the building structurally safe to allow removal of the organ and was everything done that could have been to ensure that?

Arrow International Ltd has informed the Royal Commission that the safety procedures were made clear to every person entering the building and the Engineer specified safe egress routes to be used in the event of an aftershock. Arrow International Ltd advise that this safety information has been lost on site and also in the Arrow International Ltd office as both buildings have been subsequently demolished with all files inside, therefore the information, could not be provided to the Royal Commission.

As the church building had been red placarded on 5th September, 2011, approval had to be obtained to enter the building for the purpose of removal of the organ. It is apparent from the submission that was approved by the Christchurch City Council that life safety was not the primary concern of the Christchurch City Council as it was a limited feature in both the submission, and the approval from the Council.

Without the safety procedures we are unable to assess whether sufficient safety information on the stability of the building was provided to allow for safe access, as whilst the building may have been stable under gravity load, at that time, there was sufficient awareness of the danger from aftershocks that the lateral stability of the building needed to have been thoroughly considered. The temporary securing works proposed by RD Sullivan & Associates Ltd were not all installed, and RD Sullivan recommended additional works that were not designed or installed. Structex Metro Ltd have acknowledged in their reports that there was a risk of significant aftershocks at that time, and recommended additional bracing be installed.

There appears to be a significant void in the approval process that allowed workmen to work for significant periods of time within an earthquake damaged earthquake prone building constructed of rubble filled stone masonry, during a period of aftershocks.

Upgrading of un-reinforced masonry buildings

The building at 309 Durham Street North had remained in a relatively original condition up until the recent earthquakes. The damage to the building in the 4th September, 2010 earthquake and the collapse of the building that occurred to the building in the 22nd February, 2011 earthquake demonstrates the risk that un-reinforced masonry buildings pose to the occupiers of the building and people in the vicinity of the building at the time of such an event.

The Building Act provides two opportunities for the structural upgrading of buildings. These opportunities are:

- upon a change of use, or
- implementation and enforcement of an earthquake prone building policy

For buildings constructed for a specific use, such as a church, improved public safety in a significant earthquake relies on territorial authorities adopting and implementing a meaningful

programme for strengthening and upgrading of un-reinforced masonry buildings in an earthquake prone building policy.

The delay in the Christchurch City Council implementing a policy on earthquake prone buildings may or may not have contributed to the deaths which occurred as a result of the severe 22nd February, 2011 earthquake.

Undoubtedly the Christchurch City Council's attitude to earthquake risk buildings was influenced by the perception that Christchurch was a low seismic hazard zone.

Protection of public spaces
Consideration should be given to prioritising the strengthening and upgrading of un-reinforced masonry parapets, facades and other elements that have the potential to cause loss of life in public spaces or adjoining buildings in a significant earthquake.

Owners responsibility
The delay in undertaking securing or strengthening work to the building by the building owner in order to remove the organ is of concern. The reports to the building owner were clear in terms of the risk of collapse of the building in a moderate earthquake.

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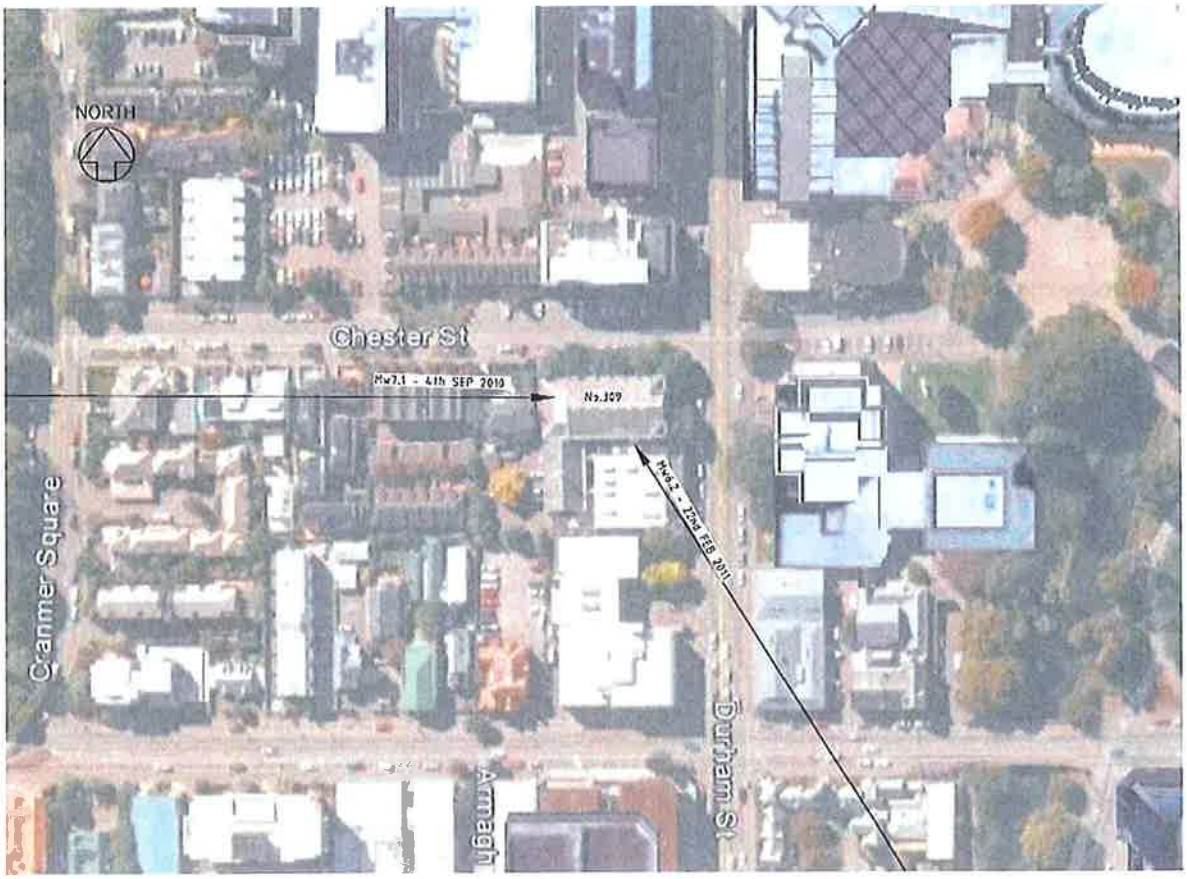
G/E110604-309 Durham Street Methodist 12 Dec 2011

APPENDIX 1

Site Plan


NORTH
Chester St
Mw7.1 - 4th SEP 2010
No.309
Mw6.3 - 22nd FEB 2011
Cranmer Square
Armagh
Durham St

APPENDIX 2

Photographs of damage following 22nd February 2011 earthquake


Ross Becker - photographer


Ross Becker - photographer


MISSION
ALDERSGATE
CENTRE