

**INDEPENDENT ASSESSMENT ON EARTHQUAKE PERFORMANCE
OF
91 Cashel Street**

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

**Report prepared by Peter C Smith and Jonathan W Devine of
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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 the performance of the building at 91 Cashel Street, 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 building was located on the north-side of Cashel Street between Oxford Terrace and Colombo Street. The location of the building in the Christchurch CBD is identified in the site plan in Appendix 1.

Description of Building

The building at 91 Cashel Street was a 3 storey un-reinforced concrete and masonry building constructed with timber roof framing and timber floors. The Christchurch City Council has no records of its construction date.

The building had a largely open façade to Cashel Street (over-clad with curtain wall glazing) and the upper storey of the rear façade was also heavily penetrated.

Compliance

A review of 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.

Christchurch City Council Policy on Earthquake Risk and Earthquake Prone Buildings

We understand that the Christchurch City Council applied for and was granted powers under the Section 301A of the Municipal Corporations Act and that the Christchurch City Council adopted a passive approach to the upgrading of earthquake risk buildings.

There is a Hazard Appendage-Survey form of February, 1992 on the Council records noting minor loose masonry, mortar deterioration and cracking.

Council also records a letter from the owners at 91 Cashel Street of August 1995 with respect to fire safety design, presumably in conjunction with alterations or fit-out for a tenancy. This letter also notes an intended life until May, 1997.

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

This policy was reviewed in early 2010.

Events Subsequent to 4th September 2010 Earthquake

The building suffered damage in the 4th September, 2010 earthquake. A Rapid Assessment-Level-1 undertaken on the 6th September, 2010 identified a fallen chimney and provided a yellow placard. This chimney fell onto No. 93 Cashel Street damaging the roof at the upper floor. On the 12th September a Rapid Assessment-Level 2 noted the chimney had been removed and also recommended an investigation by an engineer of vertical cracking in the stairwell wall. A green (low risk) posting is noted.

A Christchurch City Council Rapid Assessment-Level 2 of 14th September, 2010 is noted and a Notices Cover Sheet further requests a CPEng engineers' report on

- Vertical cracks in external walls east and west.
- Cracks observed at joints between side walls and horizontal members on Cashel Street frontage
- Concern is that if mechanism of seismic restraint is not well understood there may be repercussions during subsequent aftershocks that are not apparent at this stage.

Following the 26th December, 2010 earthquake a Rapid Assessment-Level 1 of the same day notes

- Loose bricks either end
- Horizontal cracking of south façade
- Broken glazing
- Unsafe – Red placard recommended

A letter with respect to the S124 Notice was sent by Christchurch City Council on 27th December, 2010 and a Red Placard affixed on 28th December, 2010

On 31 December, 2010 a statement by a Chartered Professional Engineer from Opus International Consultants indicates that measures to secure or strengthen the building at 91 Cashel Street had been completed to "restore the structural integrity and performance of the building to at least the condition that existed prior to the earthquake of 26/12/2010" and that "*Potentially dangerous features...have been removed or secured so reduces the danger to people's safety and of damage to other property*".

The building was significantly damaged in the 22nd February, 2011 earthquake. The top level walls on the east, west and south facades and the parapet of the north face all collapsing. The eastern wall collapsed onto No. 93-95 Cashel Street. The western wall collapsed out No. 89 Cashel Street and the south wall largely onto Cashel Street.

The building has been demolished.

Structural Failure

The upper level walls of the building at 91 Cashel Street became disconnected from the roof structure and collapsed primarily outwards with masonry elements falling onto the buildings to either side and onto Cashel Street. The east and west walls above third floor level rotated outwards and landed on the adjoining buildings at 93 – 95 Cashel Street and 89 Cashel Street

respectively. The south wall (Cashel Street façade) failed above second floor level and collapsed into Cashel Street. The north wall façade appears to have failed above the window head at level 3.

The code lateral load coefficient for a façade to an elastic responding structure in Christchurch at the time of the earthquake sequence was 1.23g at roof level of a three storey building. The analysis of un-reinforced masonry construction is not covered in the NZ Building Code. The industry uses the New Zealand Society for Earthquake Engineering guidelines 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes' 2000 and 'Assessment and Improvement of Un-reinforced Masonry Buildings for Earthquake Resistance' 2011. Calculations using these documents indicate that a sound 225 thick unreinforced masonry wall spanning from the third floor to roof level and effectively restrained at roof level would not meet code requirements without strengthening.

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 a ground acceleration of 0.9g. This level of ground acceleration equates to 1.68g acceleration at roof level. In addition, significant vertical accelerations are known to have occurred and it is probable that the façades were subjected to a vertical acceleration at the same time as being subjected to severe horizontal acceleration. Clearly failure of the poorly restrained third floor walls was almost inevitable in the severity of shaking that occurred during the 22nd February 2011 earthquake.

Issues Arising from Review

Occupancy of earthquake damaged buildings

Christchurch City Council files record that Opus International Consultants advised the Christchurch City Council on the 31 December, 2010 that potentially dangerous features had been removed. The Christchurch City Council relied on the assessment, allowing access into the building and removing cordons. Opus International Consultants advised measures to secure the building had been completed to restore the building to at least the condition that existed prior to the earthquake of 26th December, 2010

We are of the opinion that the upper floor of the building was unlikely to have withstood the severity of shaking that occurred on the 22nd February, 2011 had the building not been subjected to the previous earthquakes. The rapid assessment process is primarily focussed on addressing damage to buildings. It is suggested that prior to occupancy of an un-reinforced masonry building or public access within the fall zone of the building after a significant earthquake, the controlling authority should, establish minimum strength criteria and require an engineering assessment establishing that the building achieves the minimum strength requirement. It is also suggested that engineers receive professional CPD training on the assessment of earthquake damaged buildings.

Upgrading of un-reinforced masonry buildings

The building at 91 Cashel Street had remained in a relatively original condition up until the recent earthquakes. The damage 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 the 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
- implementation and enforcement of an earthquake prone building policy.

Improved public safety in a significant earthquake relies on territorial authorities adopting and implementing meaningful programmes for strengthening and upgrading of un-reinforced masonry buildings and enforcing the provisions for structural upgrading when a building is subject to change of use.

Records show that the Christchurch City Council was aware of the earthquake prone condition of the building in 1992. The delay in the Christchurch City Council implementing a policy on earthquake prone buildings may or may not have contributed to the damage 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.

In the interests of public safety there is a need to adequately secure the upper level walls of un-reinforced masonry buildings, particularly the facades of buildings, which present a fall hazard over public spaces or adjoining buildings. These buildings pose a serious risk to the public and those that work in or near the building in the event of a significant earthquake.

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 and adjoining buildings in a significant earthquake.

Basis of structural assessments following a significant earthquake

The Rapid Assessment process focuses on damage caused to the building by the recent earthquake. The process assumes that the risk that existed before the earthquake is acceptable in the period following the earthquake, subject to only limited damage having occurred to the building. Historically, aftershocks have caused lesser levels of shaking than the initial earthquake.

The earthquake of 22nd February, 2011 has demonstrated that the occupancy and public access in the vicinity of un-strengthened un-reinforced masonry buildings below a minimum strength level may involve an unacceptable risk to the public and occupants of these buildings. It is recommended that the basis of the rapid assessment process be reviewed.

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APPENDIX 1

Site Plans





APPENDIX 2

Photographic record of damage following 22nd February 2011 earthquake











