INDEPENDENT ASSESSMENT ON EARTHQUAKE PERFORMANCE
OF
595A Colombo 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
Spencer Holmes Ltd

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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 595A Colombo 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 before the building was demolished.

Location of Building

The building was located in Colombo Street in the block between St Asaph Street and Mollett Street.

The location of the building in the Christchurch CBD is shown on the aerial photograph of Christchurch included in Appendix 1.

Description of Building

The building at 595A Colombo Street was a two storey un-reinforced masonry building.

The building is expected to have been constructed in the early 1900's. Christchurch City Council have been unable to provide the original drawings for the building.

The building had a timber framed roof and timber first floor. Boundary walls on the ground and first floor were un-reinforced masonry.

The walls to the Colombo Street frontage were on un-reinforced masonry and were penetrated by relatively significant openings at both ground and first floor level.

Compliance

There is a record on 2nd September, 1970 of the City Engineer approving structural amendments being carried out as marked in red on the plans, but no plans were available. From the information supplied, we are uncertain as to what the structural alterations involved.

A Building Consent dated 24/07/2001 for Change of Use, Restaurant, New Deck and Access Upstairs Accommodation Alterations was issued by the Christchurch City Council. This building consent refers to a change of use. The building consent documentation also includes documentation prepared by Powell Fenwick Consultants for structural upgrading.

A Code Compliance Certificate was issued on 9th January 2004.

It appears that the building complied with the requirements of the Building Act 1991 due to the building pre-existing the Building Act, the Christchurch City Council approving the alterations and change of use in 2001 and the Code Compliance Certificate being issued in January, 2004.

Christchurch City Council Policy on Earthquake Prone Buildings

We understand that following the introduction of provisions in the Municipal Corporation Act for territorial authorities to require building owners to strengthen or demolish un-reinforced masonry buildings in 1968, the Christchurch City Council applied for and was granted powers under Section 301A of the Municipal Corporations Act. The Christchurch City Council appears to have adopted a passive approach to the upgrading of earthquake risk/prone buildings.

In a building consent application dated 2nd February, 2001 that referred to a change of use, Powell Fenwick Consultants designed the strengthening work and provided a Producer Statement PS1 for Structural Engineering Design Services in respect of the requirements of Clause B1 for Building Regulations: 1992 for part of the building work.

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

This policy was reviewed in early 2010.

Events Subsequent to 4th September 2010 Earthquake

Following the 4th September, 2010 earthquake a Rapid Assessment-Level 1 was undertaken on the buildings at 593 to 599A Colombo Street on the 5th September, 2010. The Rapid Assessment-Level 1 recorded "Minor cracking of masonry. Smashed windows at 595 Colombo, soffit of verandah buckled. Minor interior cracking in one upstairs unit inspected". The building was given a green placard.

The building is understood to have suffered only minor damage as a result of the 26th December, 2010 earthquake.

There is no record of the building having been damaged in the 26th December, 2010 earthquake.

The building suffered significant damage in the 22nd February, 2011 with the upper floor facade to Colombo Street falling outwards. The building was assigned a red placard on the 11th April 2011 and has subsequently been demolished.

Structural Failure

Significant portions of the first floor façade (primarily the parapet) of the building failed outwardly in the severe shaking during the 22nd February, 2011 earthquake.

The code lateral load coefficient for a façade to an elastic responding structure in Christchurch at the time of the earthquake sequence was 0.86g. 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 Improvements of Un-reinforced Masonry Buildings for Earthquake Resistance' 2011. Calculations using these documents indicated that a sound 225mm thick un-reinforced masonry wall spanning 3m from first floor level to roof level and effectively restrained at roof level would meet code requirements. According to Mr Simcock, the building was strengthened to a lateral load coefficient of approximately 0.18g with the façade designed to a lateral coefficient of 0.49g. Based on GNS Science records of measurements of accelerations in the Christchurch CBD

during the 22nd February, 2011 earthquake, the building was likely to have been subjected to a ground acceleration of 0.9g. This level of ground acceleration equates to an acceleration of 1.25g at first floor level. The analysis assumes no vertical acceleration occurs when the wall is subjected to the horizontal acceleration. It is known that significant vertical accelerations occurred during the 22nd February, 2011 earthquake. The street facade had significant penetrations that affect both the weight and strength of the façade. The above figures demonstrate that the earthquake shaking experienced during the 22nd February, 2011 earthquake was significantly higher than the design lateral loads. Failure of the exterior facades under the severity of shaking on the 22nd February, 2011 was to be expected.

Issues Arising from Review

Compliance

The Christchurch City Council records for the strengthening work undertaken in 2001 indicate that a consent was issued for strengthening work.

Powell Fenwick Consultants designed the strengthening work and provided a Producer Statement PS1 for Structural Engineering Design Services in respect of the requirements of Clause B1 for Building Regulations: 1992 for part of the building work. Powell Fenwick Consultants plans in 2001 included for the installation of a 360 UB portal frame across the ground floor street frontage of the restaurant and for construction of a deck at the rear of the building. The structural upgrading work provided a shear connection between the timber floor and the common party walls. Strengthening of the street façade connection to the roof and first floor framing does not appear to have been considered.

In a letter of 3rd December, 2011 Mr Simcock, of TM Consultants, a former director of Powell Fenwick Consultants, advised the Commission that "the upgrade work was designed to remove the earthquake prone status of the structure at that time. The design standard to achieve that was 33% of the "old" Christchurch loadings. This standard conflicts with the recommendations in the Powell Fenwick Consultants Limited report of 8th November 1999 where an upgrade to full code was recommended. The change was because it was subsequently determined that the alteration was not a change of use for the building and hence only the issue of earthquake prone status had to be addressed.

The upgrade work completed was to tie the wall structures into the first floor and to provide a stiff and strong bracing element to the front façade of the building below first floor level. The aim of this work was to utilise the inherent in plane strength of the brick walls and of the floor as a horizontal spanning beam. The upper floor was an internal fit-out with sufficient bracing walls."

Based on TM Consultants advice it appears that the building was only strengthened sufficiently to remove the earthquake prone status of the building. This information appears to conflict with the building consent documentation which specifically refers to a change of use.

Barriers

The building at 595A Colombo Street was green stickered following the 4th September, 2010 earthquake.

The Canterbury earthquake series has demonstrated that after a significant earthquake, the risk of a significant after shock is high and controlling authorities need to recognise the risk of failure of

building facades to un-reinforced masonry buildings in a subsequent aftershock if a repeat of the tragic loss of life that occurred on the 22nd February 2011 is to be prevented. This would require barriers to be erected to isolate the full extent of the fall zone of un-reinforced masonry buildings strengthened to less than close to current code requirements during any period of increased seismicity following a significant earthquake. The risk of façade failures in a significant aftershock needs to be balanced with the economic consequences of preventing occupancy and public access in the fall zone of inadequately strengthened un-reinforced masonry buildings.

Performance of strengthened building

A significant aspect of the earthquake damage to the building is the failure of the street facade above first floor level in the 22nd February, 2011 earthquake.

The performance of the building under the earthquakes on the 4th September, 2010 and 26th December, 2010 demonstrated that even moderate strengthening work reduced damage levels and achieved an acceptable performance in moderate earthquake shaking. The substantial damage that occurred in the 22nd February, 2011 earthquake demonstrated the vulnerability of the façade of these buildings to severe out of plane earthquake shaking.

GNS Science record that the displacements, velocities and accelerations imposed by the 22nd February, 2011 earthquake significantly exceed the requirements of 33% NZS 4203. Given the brittle nature of the un-reinforced masonry walls, the failure that occurred was almost inevitable under the directionality and severity of shaking that occurred on 22nd February, 2011.

While strengthening of un-reinforced masonry buildings to 33% of the requirements of NZS 4203 : 1976 is expected to improve the performance of those buildings in a moderate earthquake, those buildings will remain vulnerable to severe earthquake shaking.

Vertical acceleration effects

It is likely that the significant vertical accelerations that occurred in the 22nd February, 2011 earthquake contributed to the failure of the un-reinforced masonry elements. It is suggested that good practice include consideration of vertical acceleration effects on un-reinforced masonry walls, particularly in the upper level of un-reinforced masonry buildings. Un-reinforced masonry elements to the upper storey of buildings are particularly vulnerable to the combined effects of vertical acceleration and out of plane shaking.

Criteria for occupancy

The criteria for occupancy of un-reinforced masonry buildings after a damaging earthquake require further consideration. It is particularly important that engineers have a clear brief when assessing the condition of un-reinforced masonry buildings damaged in earthquake. It is suggested that the controlling authority should nominate minimum strength levels that engineers assess buildings to prior to occupancy or public access within the fall zone of facades.

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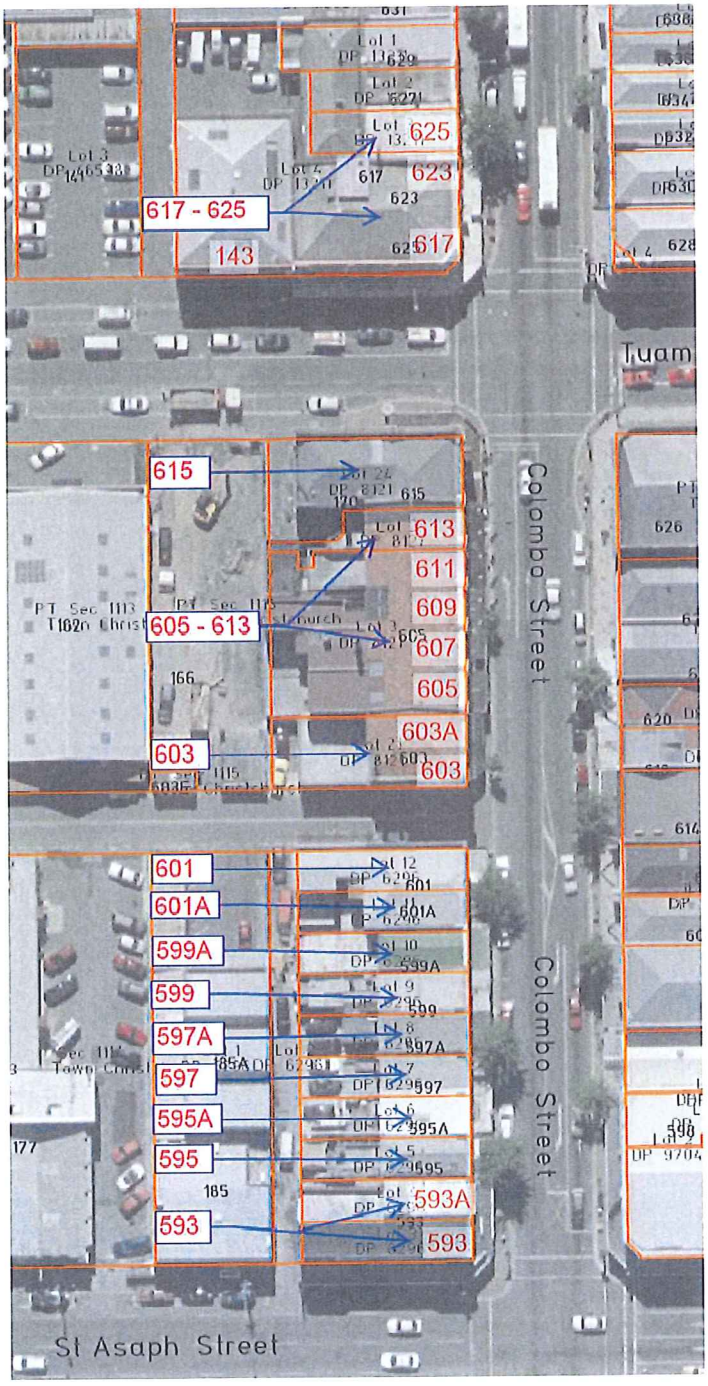
APPENDIX 1

Site Plans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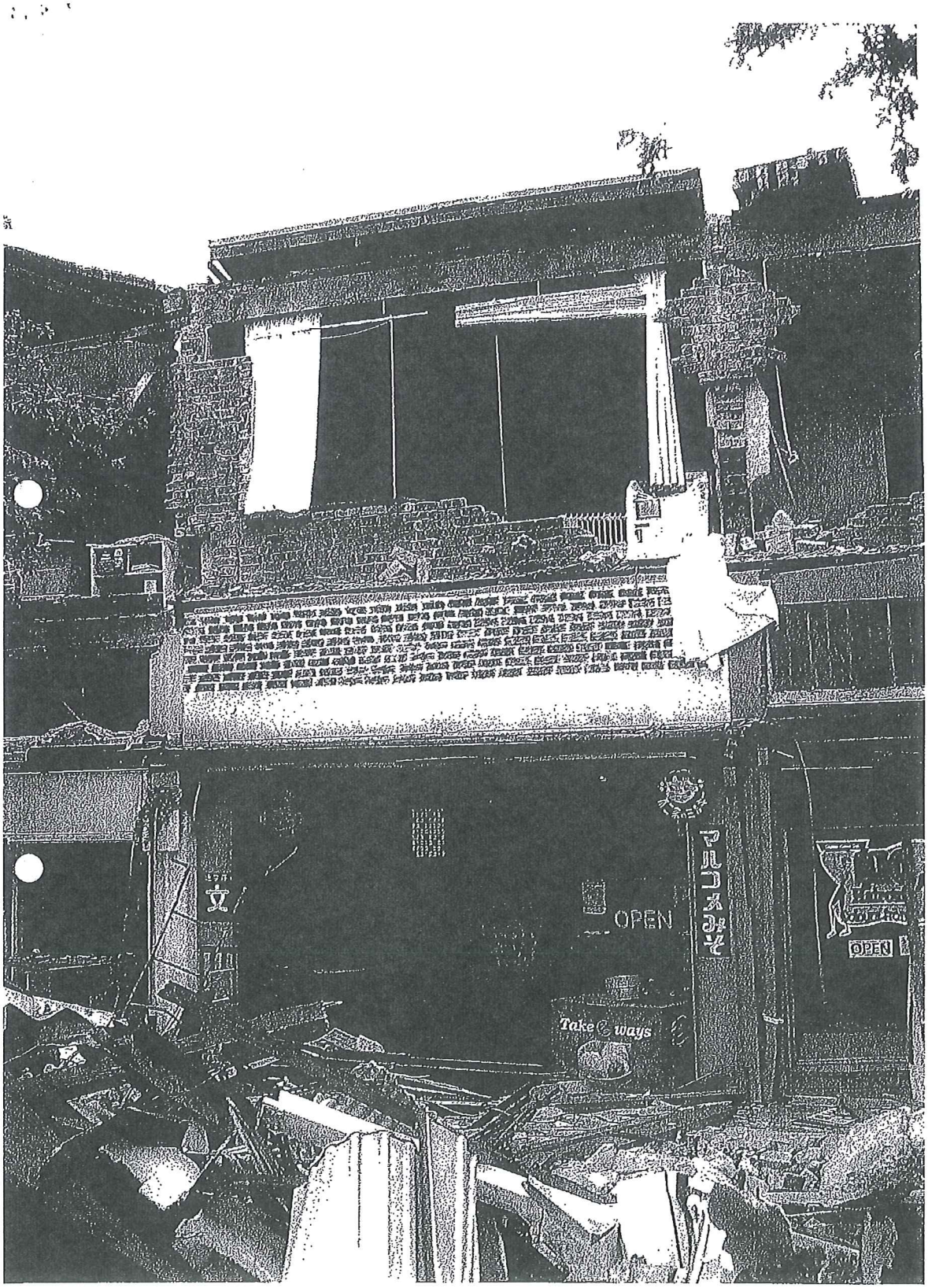
593
Colombo Street
Colombo Street
St Asaph Street
Tuam


NORTH
Tuam St
Mollett St
No.601
Mw7.1 - 4th SEP 2010
No.595A
No.593
Colombo St
Mw6.2 - 22nd FEB 2011
Saint Asaph St
Welles St

APPENDIX 2

Photos taken after 22nd February, 2011 earthquake.
- (Note Date on photos assessed 1 year out)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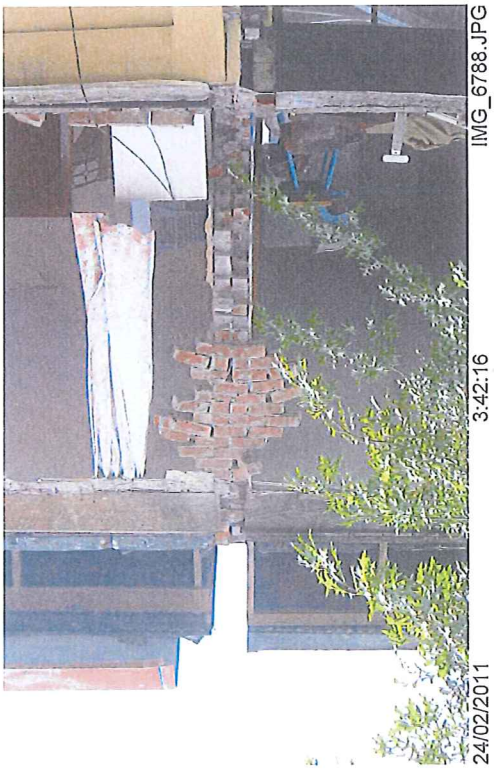

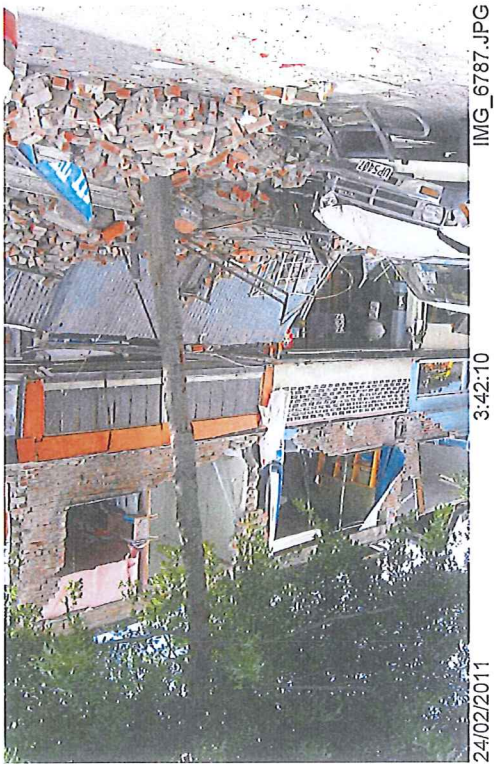

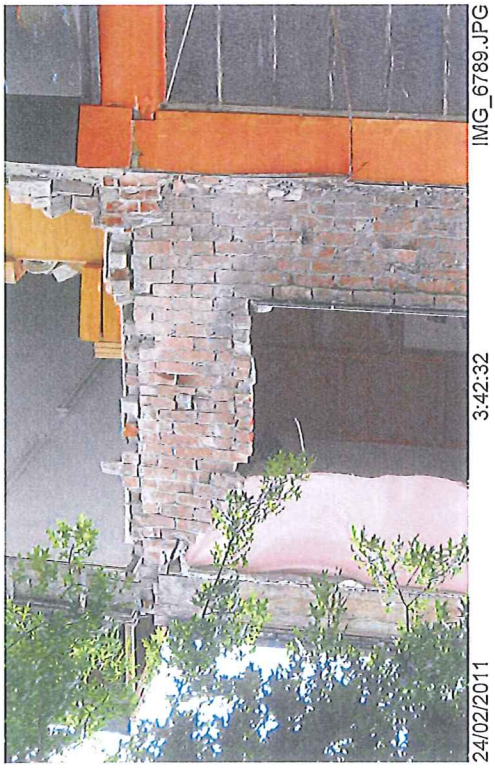

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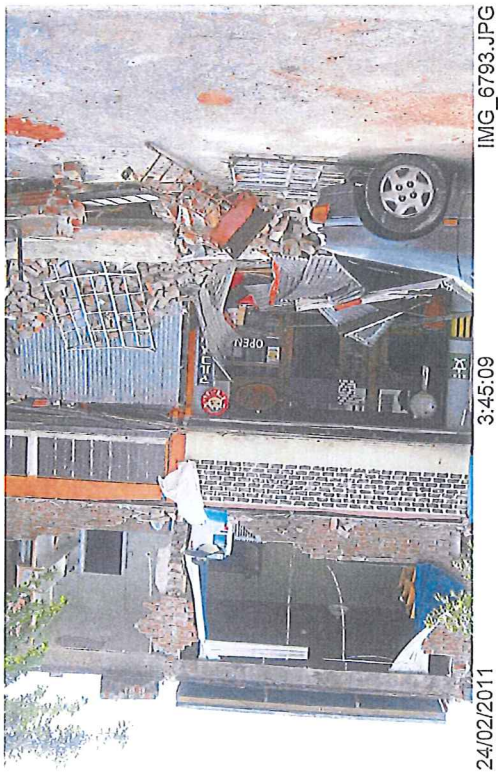

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