

**INDEPENDENT ASSESSMENT ON EARTHQUAKE PERFORMANCE
OF**

738 COLOMBO STREET

FOR

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

**Report prepared by Peter C Smith and Jonathan Devine
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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 738 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 on the east side of Colombo Street between Armagh Street and Gloucester Street. The location of the building in the Christchurch CBD is identified in the site plan in Appendix 1. The direction of the epicentres of the main earthquake are also shown on the aerial photo.

Description of Building

The building at 738 Colombo Street was a two storey building of combined un-reinforced masonry and early reinforced concrete construction with timber roof framing and timber first floor.

The building had significant openings to the ground floor street frontage and the upper floor façade had moderate openings for windows. The building had reasonably high parapets to the Colombo Street frontage.

The building is recorded as being constructed in 1937. The building has concrete beam and column construction with infill brick to the north wall, concrete panels to the upper levels of the east and west walls and structural steel columns to the south wall. The steel columns support steel beams that in turn support a timber floor. The roof is supported on timber trusses supported off the north and south walls. The building adjoins a four storey building at 736 Colombo Street which is recorded as being constructed as a two storey building and extended with an extra storey in each of 1925 and 1926. There is a single storey building at the rear of the two storey building.

Compliance

The original building appears to have been constructed with six steel internal columns supporting the first floor. There are record drawings for replacing the existing steel columns supporting the first floor with steel plated girders spanning from the north to the south walls. These girders supported the original 450mm x 150mm (18 x 6) RSJ beams which in turn supported the timber floor. The drawings were dated as approved by the Christchurch City Council on the 14th January, 1958. The alterations to the building appear to consider gravity loading but do not consider earthquake loading.

Seismic strengthening of the two storey building was undertaken in two stages. Stage 1 was granted a building consent in July, 1991. A building consent for Stage 2 was issued in 1996. The work was recorded as having been completed in March, 1997. Seismic strengthening is reported by the Christchurch City Council to have been undertaken to a level of 0.1g.

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 the alterations or change of use occurring since the introduction of the Building Act having been approved by the Christchurch City Council.

Christchurch City Council Policy on 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.

The Christchurch City Council, City Engineers Department wrote to the owners of the buildings 736 to 744 Colombo Street on 30th March, 1976 advising that the Christchurch City Council had been empowered to administer Section 301A of the Municipal Corporations Act. The City Engineers Department advised that in their opinion, the buildings at 736 to 744 Colombo Street would not comply with the provisions of this particular section of the Act, which requires buildings to be of a sufficient strength to resist a moderate earthquake. As the area adjacent to the buildings was subject to heavy pedestrian traffic, the City Engineer required to be informed of the company's intention with regard to the future of the buildings. The City Engineer advised that as the northern boundary wall was a party wall shared with the adjoining property, the City Engineer had also written to the adjoining owners.

There appears to be no response from Pyne Gould Guinness Ltd or that the Christchurch City Council followed with Pyne Gould Guinness Ltd in respect of this matter.

There is also a record on 29th August, 1983 of the Christchurch City Council requiring that a report be obtained from a registered Consulting Engineer which investigated compliance of the buildings with Section 624 of the Local Government Act, which required that the buildings to possess resistance against earthquake loading. The property report comments "Report and two letters on file. No evidence of new work".

There was a Seismic Risk Building Survey of the property undertaken by the Christchurch City Council. The survey appears incomplete.

A Hazard Appendage Survey form on the Council files noted a cracked parapet, cornice and wall along the Colombo Street frontage on the 3rd November, 1992. There is also a record of cracking to the brickwork at the rear of the property.

Seismic strengthening of the two storey building was undertaken in two stages between July, 1991 and March, 1997.

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

This policy was reviewed in early 2010.

Strength Assessment

A strength assessment of the building 738 Colombo Street, along with the adjoining four storey building 736 Colombo Street, was undertaken by Buchanan and Fletcher in 1991. Buchanan and Fletcher commented in their report of 17th July 1991: *The two storey structure has earthquake*

resistance in the east west direction via a concrete frame to the north wall and concrete encased steel columns to the south wall. With the floor being timber, the bulk of the earthquake loads are generated by the front and rear concrete walls. In the north-south direction the only resisting elements are the columns bending about the minor axis. Stiffness considerations and the fact that the building is tied to the adjacent 4 storey structure at the column locations implies that the bulk of the earthquake resistance in this direction being provided by that structure.

Buchanan and Fletcher recommended the following remedial works:

- a) *The brick parapets to the north and east should be lowered and capped with a concrete band or, in the case of the east wall, removed altogether.*
- b) *Provide independent steel column support to the roof at the south east corner.*
- c) *The upper level concrete walls are 225mm thick reinforced each face. These require securing at the ceiling and first floor levels using an epoxy bolting system. Loads would then be transferred to the north and south resisting elements via steel bracing at ceiling level and horizontal ply and steel beams at floor level.*
- d) *The support details of newer main floor beams are unknown and their connections should be check to ensure they are not vulnerable during horizontal movement of the floor, etc.*

In conjunction with this the perimeter of the timber floor should be secured with epoxy dowels to the surrounding concrete work.

Buchanan and Fletcher recommended that Items (c) and (d) should be addressed immediately with items (a) and (b) being undertaken within the next 12 months.

The Christchurch City Council hold records of the documentation prepared by Buchanan and Fletcher Ltd. While the work shown on Buchanan and Fletcher Ltd's drawings was apparently constructed, the work does not appear to relate to the two storey building.

In June, 1996 Buchanan and Fletcher wrote to the Christchurch City Council advising *that Items 3.3(c) and (d) were completed in 1991. The brick parapets at the north and east, Items 3.3(a) and (b) are to be strengthened in accordance with sketches 1 and 2. The strengthening work would strain the parapets and brick walls as opposed to lowering or removal. With the east wall restrained, the roof in the south east corner will have improved support.*

Buchanan and Fletcher advised that the strengthening was based on out of plane loading criteria as outlined in New Zealand National Society of Earthquake Engineering draft guidelines Section 5.5.

Events Subsequent to 4th September 2010, Earthquake

The building appears to have suffered only minimal damage in the 4th September, 2010 earthquake. The building at 738 Colombo Street was inspected by Powell Fenwick Consultants on 4th September, 2010. In a letter of 6th September, 2010 Powell Fenwick advised the building owner that *preliminary indications are that this building is not in immediate danger of structural collapse, noting only minor damage to linings and no items requiring immediate attention.*

There appears to have been no damage as a result of the 26th December, 2010 earthquake, although there is no indication that the building was inspected by an engineer following that event.

We have sighted no record of any rapid assessment having been undertaken on the building following the 4th September, 2010 or 26th December, 2010 earthquakes. The Christchurch City Council has advised that a Rapid Assessment-Level 1 was undertaken on the 5th September, 2010. We assume that the assessment assigned the building a green placard as the assessment did not recommend a Rapid Assessment-Level 2.

A failure of the building façade to Colombo Street occurred during the 22nd February, 2011 earthquake. Powell Fenwick subsequently reported to McLarens Young International, insurance assessors, on 9th September, 2011 on damage resulting from 22nd February, 2011 earthquake, noting that the building at 736 Colombo Street had suffered severe and wide spread damage, in particular to the upper levels of the building. There was concern that the building could fall over the building 738 Colombo Street in a moderate earthquake. Powell Fenwick recommended demolition of both buildings.

The building has subsequently been demolished.

Structural Failure

Although we are unable to inspect the building prior to demolition, we have been able to review photos of the damage prior to demolition.

From the photographs it would appear that the front façade above first floor window sill level rotated outwards from the support at the window sill level, collapsing onto the footpath in Colombo Street as a result of the severe shaking experienced during the 22nd February, 2011 earthquake. It is also evident that there was significant damage to the wall of the building at 736 Colombo Street where it adjoined the wall of the building 738 Colombo Street. We are of the opinion that pounding of the two storey building by the four storey building may have contributed to the failure of the west wall façade to the two storey building.

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. 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 accelerations of 0.9g. This level of ground acceleration equates to an acceleration of 1.25g at first floor level. In addition it is likely that the façade was subjected to vertical acceleration at the time the wall was subjected to the horizontal acceleration.

Although the wall had apparently been secured to the New Zealand National Society of Earthquake Engineering recommendations, the level of shaking experienced during the 22nd February, 2011 earthquake far exceeded this level of securing and failure of the wall was almost inevitable.

Issues Arising from Review

Upgrading of un-reinforced masonry and early reinforced concrete buildings

The building at 738 Colombo Street had been significantly altered since its original construction with the removal of all internal columns. The building was in part reliant on the building at 736

Colombo Street for lateral support. The building had been strengthened to the requirements of the New Zealand National Society of Earthquake Engineering recommendations in the period 1991 to 1997.

The damage that occurred to the building in the 22nd February, 2011 earthquake demonstrates the risk that un-reinforced masonry and early reinforced concrete 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
- 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 and early reinforced concrete buildings and enforcing the provisions for structural upgrading when a building is subject to a change of use.

We suggest that due to the extensive damage and loss of life that occurred as a result of the failure of façades in the 22nd February, 2011 earthquake, consideration be given to reviewing the standards for securing the façades to un-reinforced masonry and early reinforced concrete buildings.

Research

The methods for adequately restraining the facades of un-reinforced masonry or early reinforced concrete buildings needs further consideration.

The Canterbury earthquake sequence was notable for the level of intense but short duration shaking. Research is recommended on extending the knowledge learnt from the failures in the Canterbury earthquake series to improve the performance of un-reinforced or early reinforced concrete masonry, façades exposed to severe longer duration shaking.

The extensive failure of upper level façades justifies further research on methods of more accurately assessing the strength of un-reinforced masonry and early reinforced concrete façades with low levels of axial load, and where vertical acceleration can potentially further reduce the strength of these vulnerable elements.

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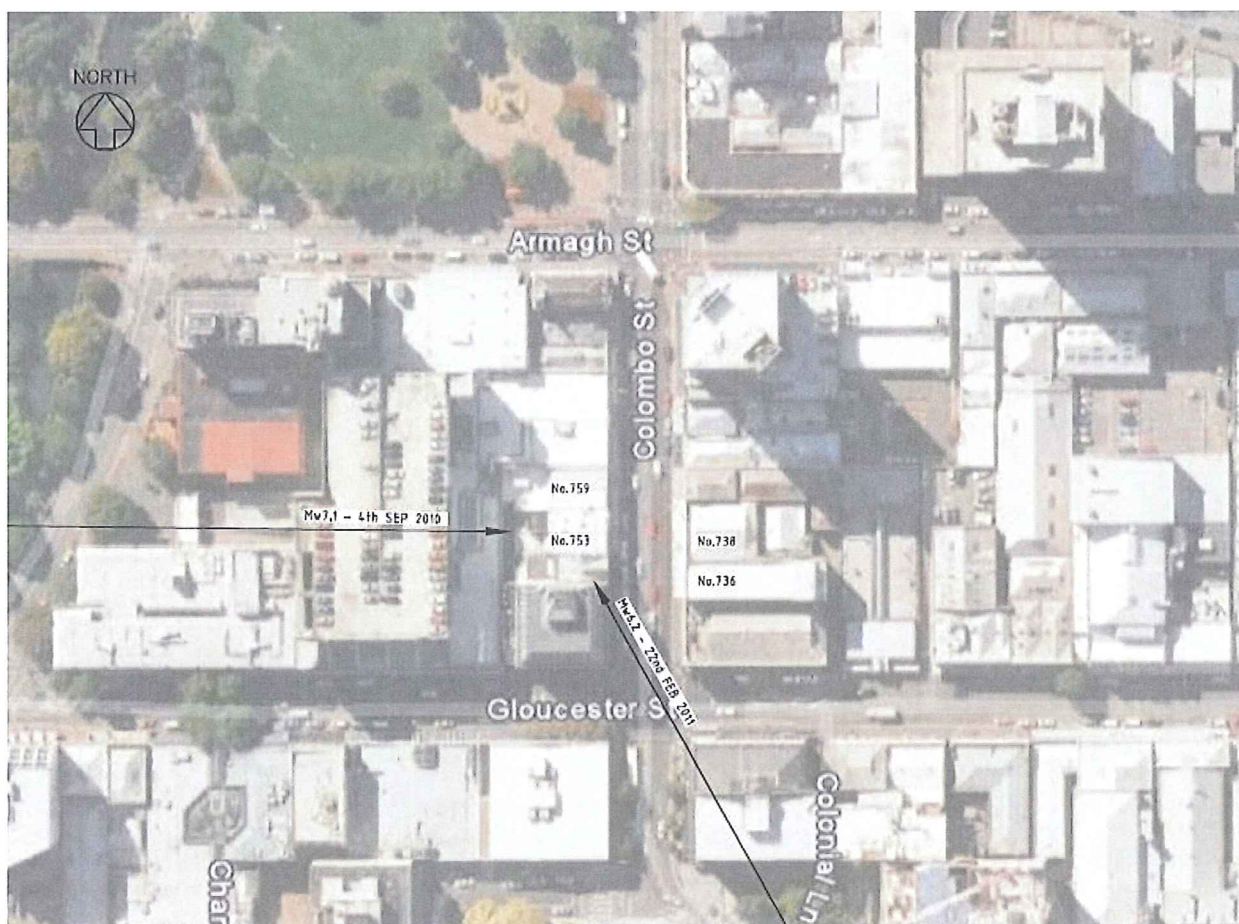
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APPENDIX 1

Site Plans





APPENDIX 2

Photos of façade failure following the 4th September, 2010 earthquake



