Christchurch City Council

Fletcher Place Housing Complex PRO 0230

Detailed Engineering Evaluation

Quantitative Assessment Report

Christchurch City Council

Fletcher Place Housing Complex

Quantitative Assessment Report

Fletcher Place, Riccarton, Christchurch

Prepared By

Andrew Sawers
Building Technologist

Reviewed By

Lachlan Howat
Graduate Structural Engineer

Approved for Release By

Mary Ann Halliday
Senior Structural Engineer

Opus International Consultants Ltd
Christchurch Office

20 Moorhouse Avenue
PO Box 1482, Christchurch Mail Centre, Christchurch 8140
New Zealand

Telephone: +64 3 363 5400
Facsimile: +64 3 365 7858

Date: November 2013
Reference: 6-QC340.00
Status: Final

Summary

Fletcher Place Housing Complex
PRO 0230

Detailed Engineering Evaluation
Quantitative Report - Summary
Final

Background

This is a summary of the quantitative report for the Fletcher Place Housing Complex, and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This assessment covers the 68 residential units on the site.

Key Damage Observed

The residential units suffered minor damage to non-structural elements.

Structural damage to the residential units was generally minor and was limited to the wall and ceiling lining and cracking of the concrete foundation perimeter footing in some residential unit blocks. There is moderate damage to the roofline between units 10-11, possibly due to the block fire wall being subject to differential settlement.

Level Survey

All floor slopes assessed were less than the 5mm/m limitation set out in the MBIE guidelines [6].

Critical Structural Weaknesses

No critical structural weaknesses were found in any of the buildings.

Indicative Building Strength

Table A: Summary of Seismic Performance by Blocks

Block	NBS%	Floor Levels	Gib Nail Spacings
PRO 0230 B001 (Block A)	62%	Pass	Pass
PRO 0230 B002 (Residents Lounge)	100%	Pass	Pass
PRO 0230 B003 (Block B)	62%	Pass	Pass
PRO 0230 B004 (Block C)	62%	Pass	Pass
PRO 0230 B005 (Block D)	62%	Pass	Pass
PRO 0230 B006 (Block E)	62%	Pass	Pass
PRO 0230 B007 (Block F)	62%	Pass	Pass
PRO 0230 B008 (Block G)	62%	Pass	Pass

PRO 0230 B009 (Block H)	62%	Pass	Pass
PRO 0230 B010 (Block I)	62%	Pass	Pass
PRO 0230 B011 (Block J)	54%	Pass	Pass
PRO 0230 B012 (Block K)	54%	Pass	Pass
PRO 0230 B013 (Block L)	54%	Pass	Pass
PRO 0230 B014 (Block M)	62%	Pass	Pass
PRO 0230 B015 (Block N)	62%	Pass	Pass
PRO 0230 B016 (Block O)	62%	Pass	Pass

No buildings on the site are considered to be earthquake prone.

The residential units of Type A have a capacity of 54% NBS as limited by the in-plane shear capacity of the timber-framed shear walls in the longitudinal direction. They are deemed to be a 'moderate risk' in a design seismic event according to NZSEE guidelines.

The residential units of Type B have a capacity of 62% NBS as limited by the in-plane shear capacity of the timber-framed shear walls in the longitudinal direction. They are deemed to be a 'moderate risk' in a design seismic event according to NZSEE guidelines.

The residents lounge has a capacity of 100% NBS as limited by the in-plane shear capacity of the timber-framed shear walls in the transverse direction. They are deemed to be a 'low risk' in a design seismic event according to NZSEE guidelines.

Increasing the number of nails in the plasterboard will not significantly improve the strength of the buildings.

Recommendations

It is recommended that;

- Strengthening schemes be developed to increase the seismic capacity of the residential units to at least 67%NBS.
- Veneer at height (gable ends) have the veneer ties checked.
- Cosmetic repairs be undertaken as required.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council to undertake a detailed seismic assessment of the Fletcher Place Housing Complex, located at Fletcher Place, Riccarton, Christchurch, following the Canterbury earthquake sequence since September 2010. The site was visited by Opus International Consultants on 16 September 2013.

The purpose of the assessment is to determine if the buildings in the village are classed as being earthquake prone in accordance with the Building Act 2004.

The seismic assessment and reporting have been undertaken based on the qualitative and quantitative procedures detailed in the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) [2] [3] [4] [5].

2 Compliance

This section contains a brief summary of the requirements of the various statutes and authorities that control activities in relation to buildings in Christchurch at present.

2.1 Canterbury Earthquake Recovery Authority (CERA)

CERA was established on 28 March 2011 to take control of the recovery of Christchurch using powers established by the Canterbury Earthquake Recovery Act enacted on 18 April 2011. This act gives the Chief Executive Officer of CERA wide powers in relation to building safety, demolition and repair. Two relevant sections are:

Section 38 – Works

This section outlines a process in which the chief executive can give notice that a building is to be demolished and if the owner does not carry out the demolition, the chief executive can commission the demolition and recover the costs from the owner or by placing a charge on the owners' land.

Section 51 – Requiring Structural Survey

This section enables the chief executive to require a building owner, insurer or mortgagee to carry out a full structural survey before the building is re-occupied.

We understand that CERA require a detailed engineering evaluation to be carried out for all buildings (other than those exempt from the Earthquake Prone Building definition in the Building Act). CERA have adopted the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011. This document sets out a methodology for both initial qualitative and detailed quantitative assessments.

It is anticipated that a number of factors, including the following, will determine the extent of evaluation and strengthening level required:

1. The importance level and occupancy of the building.

2. The placard status and amount of damage.
3. The age and structural type of the building.
4. Consideration of any critical structural weaknesses.

Christchurch City Council requires any building with a capacity of less than 34% of New Building Standard (including consideration of critical structural weaknesses) to be strengthened to a target of 67% as required under the CCC Earthquake Prone Building Policy.

2.2 Building Act

Several sections of the Building Act are relevant when considering structural requirements:

Section 112 - Alterations

This section requires that an existing building complies with the relevant sections of the Building Code to at least the extent that it did prior to the alteration. This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

The Earthquake Prone Building policy for the territorial authority shall apply as outlined in Section 2.3 of this report.

Section 115 – Change of Use

This section requires that the territorial authority is satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'.

This is typically interpreted by territorial authorities as being 67% of the strength of an equivalent new building or as near as practicable. This is also the minimum level recommended by the New Zealand Society for Earthquake Engineering (NZSEE).

Section 121 – Dangerous Buildings

This section was extended by the Canterbury Earthquake (Building Act) Order 2010, and defines a building as dangerous if:

1. In the ordinary course of events (excluding the occurrence of an earthquake), the building is likely to cause injury or death or damage to other property; or
2. In the event of fire, injury or death to any persons in the building or on other property is likely because of fire hazard or the occupancy of the building; or
3. There is a risk that the building could collapse or otherwise cause injury or death as a result of earthquake shaking that is less than a 'moderate earthquake' (refer to Section 122 below); or
4. There is a risk that other property could collapse or otherwise cause injury or death; or
5. A territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone (EPB) if its ultimate capacity would be exceeded in a 'moderate earthquake' and it would be likely to collapse causing injury or death, or damage to other property.

A moderate earthquake is defined by the building regulations as one that would generate loads 33% of those used to design an equivalent new building.

Section 124 – Powers of Territorial Authorities

This section gives the territorial authority the power to require strengthening work within specified timeframes or to close and prevent occupancy to any building defined as dangerous or earthquake prone.

Section 131 – Earthquake Prone Building Policy

This section requires the territorial authority to adopt a specific policy for earthquake prone, dangerous and insanitary buildings.

2.3 Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in October 2011 following the Darfield Earthquake on 4 September 2010.

The policy includes the following:

1. A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;

2. A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;

3. A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,

4. Repair works for buildings damaged by earthquakes will be required to comply with the above.

The council has stated their willingness to consider retrofit proposals on a case by case basis, considering the economic impact of such a retrofit.

If strengthening works are undertaken, a building consent will be required. A requirement of the consent will require upgrade of the building to comply 'as near as is reasonably practicable' with:

- The accessibility requirements of the Building Code.

- The fire requirements of the Building Code. This is likely to require a fire report to be submitted with the building consent application.

Where an application for a change of use of a building is made to Council, the building will be required to be strengthened to 67% of New Building Standard or as near as is reasonably practicable.

2.4 Building Code

The Building Code outlines performance standards for buildings and the Building Act requires that all new buildings comply with this code. Compliance Documents published by The Department of Building and Housing can be used to demonstrate compliance with the Building Code.

On 19 May 2011, Compliance Document B1: Structure, was amended to include increased seismic design requirements for Canterbury as follows:

- Increase in the basic seismic design load for the Canterbury earthquake region (Z factor increased to 0.3 equating to an increase of 36 – 47% depending on location within the region);
- Increased serviceability requirements.

2.5 Institution of Professional Engineers New Zealand (IPENZ) Code of Ethics

One of the core ethical values of professional engineers in New Zealand is the protection of life and safeguarding of people. The IPENZ Code of Ethics requires that:

Members shall recognise the need to protect life and to safeguard people, and in their engineering activities shall act to address this need.

1.1 Giving Priority to the safety and well-being of the community and having regard to this principle in assessing obligations to clients, employers and colleagues.

1.2 Ensuring that responsible steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.

All recommendations on building occupancy and access must be made with these fundamental obligations in mind.

3 Earthquake Resistance Standards

For this assessment, the building's earthquake resistance is compared with the current New Zealand Building Code requirements for a new building constructed on the site. This is expressed as a percentage of new building standard (%NBS). The loadings are in accordance with the current earthquake loading standard NZS1170.5 [1].

A generally accepted classification of earthquake risk for existing buildings in terms of %NBS that has been proposed by the NZSEE 2006 [2] is presented in Figure 1 below.

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance: Legal Requirement	Improvement of Structural Performance: NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)	Unacceptable	Unacceptable

Figure 1: NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE Guidelines [2]

Table 1 below compares the percentage NBS to the relative risk of the building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year).

Table 1: %NBS compared to relative risk of failure

Percentage of New Building Standard (%NBS)	Relative Risk (Approximate)
>100	<1 time
80-100	1-2 times
67-80	2-5 times
33-67	5-10 times
20-33	10-25 times
<20	>25 times

3.1 Minimum and Recommended Standards

Based on governing policy and recent observations, Opus makes the following general recommendations:

3.1.1 Occupancy

The Canterbury Earthquake Order[1] in Council 16 September 2010, modified the meaning of "dangerous building" to include buildings that were identified as being EPB's. As a result of this, we would expect such a building would be issued with a Section 124 notice, by the Territorial Authority, or CERA acting on their behalf, once they are made aware of our assessment. Based on information received from CERA to date and from the MBIE guidance document dated December 2012 [6], this notice is likely to prohibit occupancy of the building (or parts thereof), until its seismic capacity is improved to the point that it is no longer considered an EPB.

3.1.2 Cordoning

Where there is an overhead falling hazard, or potential collapse hazard of the building, the areas of concern should be cordoned off in accordance with current CERA/territorial authority guidelines.

3.1.3 Strengthening

Industry guidelines (NZSEE 2006 [2]) strongly recommend that every effort be made to achieve improvement to at least 67%NBS. A strengthening solution to anything less than 67%NBS would not provide an adequate reduction to the level of risk.

It should be noted that full compliance with the current building code requires building strength of 100%NBS.

3.1.4 Our Ethical Obligation

In accordance with the IPENZ code of ethics, we have a duty of care to the public. This obligation requires us to identify and inform CERA of potentially dangerous buildings; this would include earthquake prone buildings.

[1] This Order only applies to buildings within the Christchurch City, Selwyn District and Waimakariri District Councils authority.

4 Background Information

4.1 Building Descriptions

The site contains 68 residential units separated into two types of floor plan (constructed in 1965 and 1971) and a resident's lounge (constructed in 1994). A site plan showing the location of the units, numbered 1 to 69 (excluding 13), is shown in Figure 2. Figure 3 shows the location of the site in Christchurch City. The units are grouped together to form blocks of either four or six units.

Figure 2: Site plan of Fletcher Place Housing Complex.

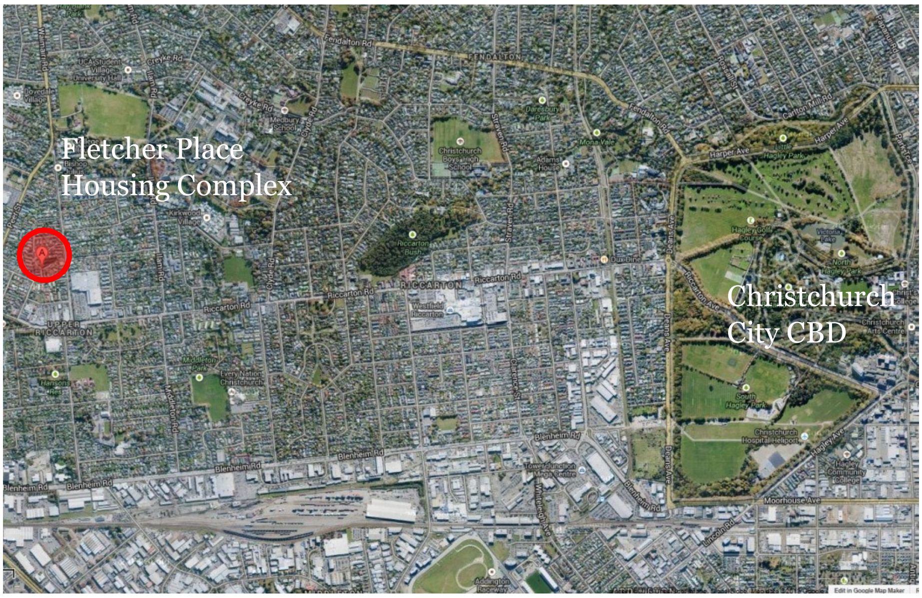


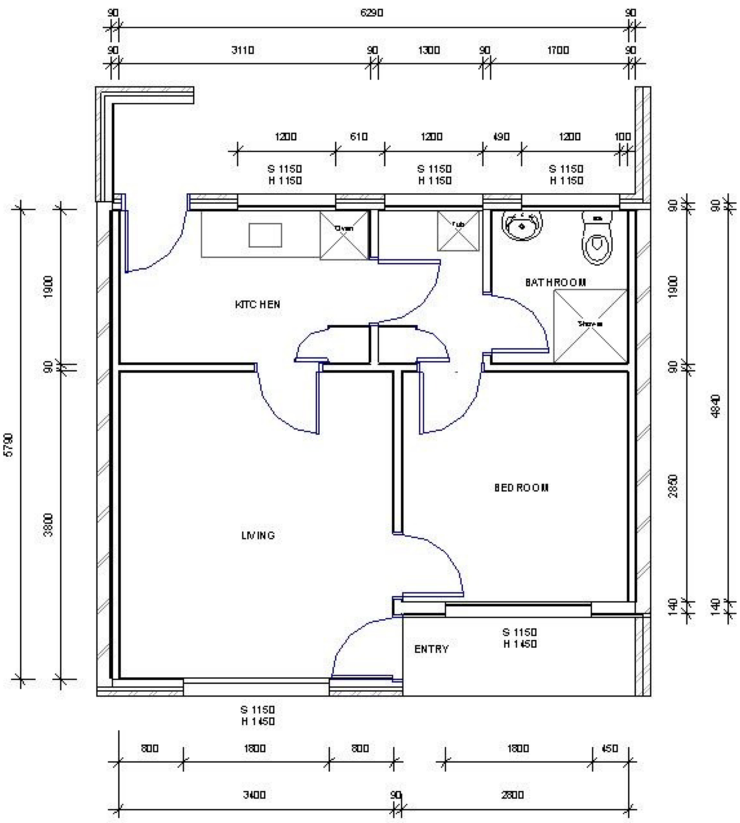
Figure 3: Location of site relative to Christchurch City CBD (Source: Google Earth).

The residential units (Type A and B) are timber-framed buildings with diagonal timber braces. The roof structure comprises of timber roof framing supporting timber sarking and light-weight metal roofs. The walls and ceilings are lined with plasterboard. External walls are clad with brick veneer, blockwork and vertical weatherboards. Type A foundations consist of a concrete slab on grade with perimeter strip footings. Type B foundations consist of a concrete perimeter wall with concrete piles supporting a timber floor.

The units are separated by 190mm block masonry fire walls which (based on information available) have reinforcement to the perimeter. We note that the end wing walls are likely to be 2 wythes of veneer tied together.

The residents lounge is a timber-framed building with brick cladding. Bracing consists of diagonal steel angle braces in the longitudinal direction and 12mm plywood bracing in the transverse direction. The walls are internally lined with 9.5mm plasterboard throughout. Low ceilings are lined with 12mm plasterboard while the pitched ceilings are lined with 9mm plasterboard. The roofs are clad in lightweight metal and are supported by timber framing. The foundations are reinforced concrete slabs with reinforced concrete ground beams under external and bracing walls.

Figure 4 & Figure 6 shows a typical floor plan of two different types of residential unit produced from site measurements by Opus. Figure 5 shows a cross section for Type A used in calculations. Figure 7 shows a floor plan of the residents lounge.



Type A Unit

Figure 4: Typical partial floor plan of residential unit blocks.

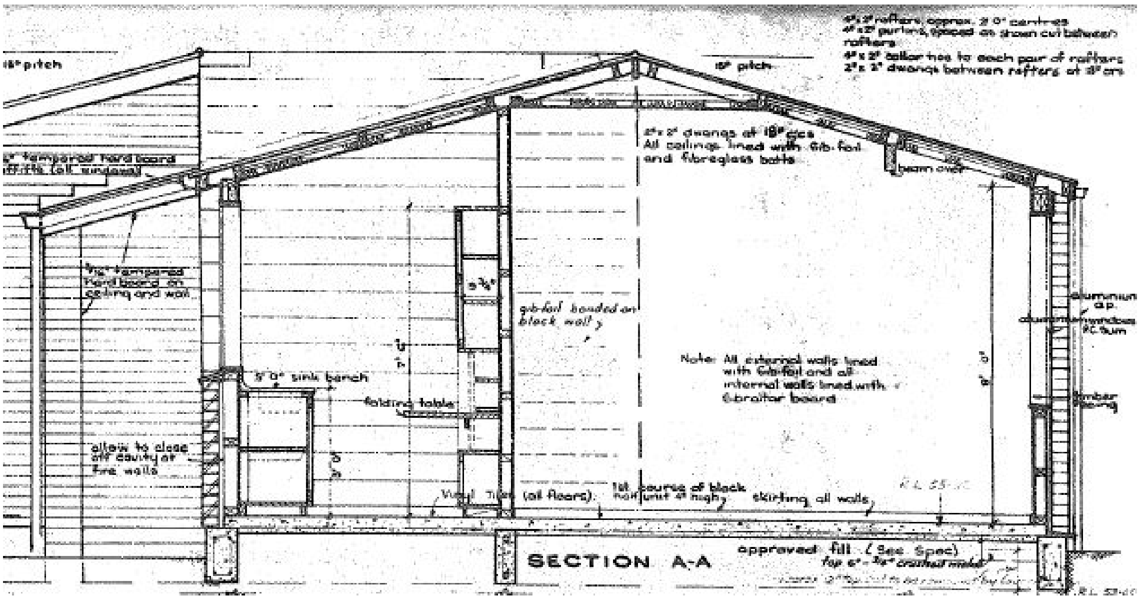
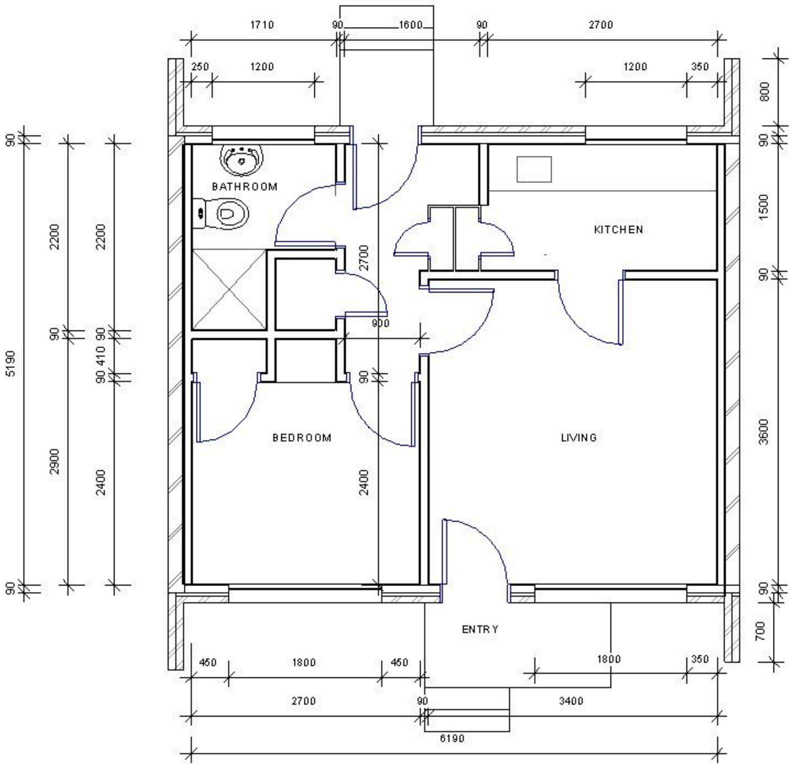


Figure 5: Type A cross section.



Type B Unit

Figure 6: Typical partial floor plan of Type B residential unit.

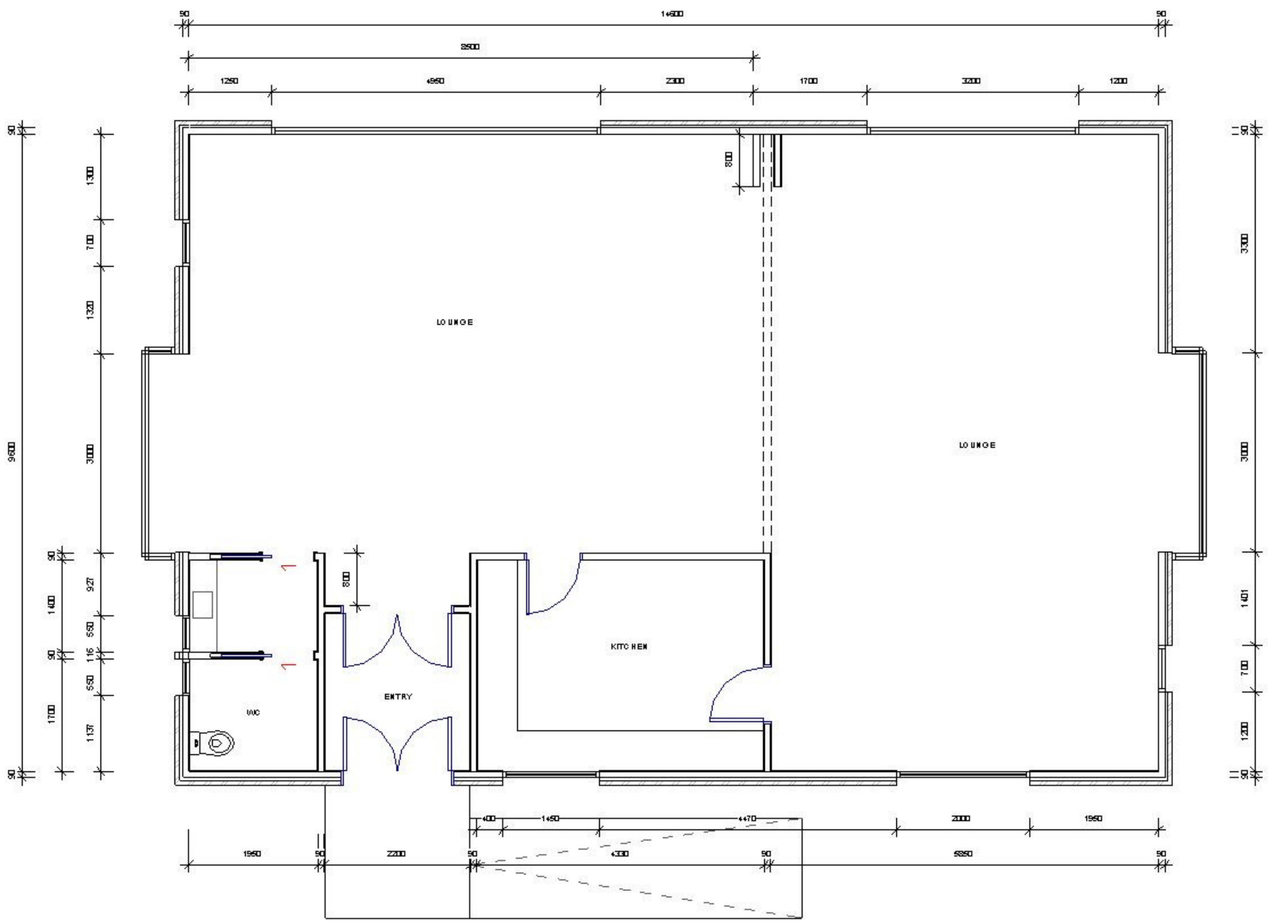


Figure 7: Residents Lounge plan.

4.2 Survey

4.2.1 Post 22 February 2011 Rapid Assessment

A structural (Level 2) assessment of the buildings/property was undertaken on 10 March 2011 by Opus International Consultants.

4.2.2 Level Survey

A full level survey was not deemed to be necessary at Fletcher Place as it is located in a TC1 zone. Properties in TC1 zones suffered minimal damage due to liquefaction and/or settlement. In lieu of a full level survey, a laser level was placed in each unit so that differentials in vertical levels could be measured at the extreme ends of the unit. These values could then be used to determine the floor slope of the entire unit. For this site, all floor slopes were less than the 5mm/m limitation set out in the MBIE guidelines.

4.2.3 Nail Spacing

Nail spacing was checked in a number of units and was consistently 250mm.

Table 2: Summary of Level Survey

Block	Unit No.	Comment	Maximum Fall*
A	1	Pass	-
	2	No Access	-
	3	Pass	-
	4	Pass	-
B	5	Pass	-
	6	Pass	-
	7	Pass	-
	8	Pass	-
C	9	Pass	-
	10	Pass	-
	11	No Access	-
	12	Pass	-
D	14	Pass	-
	15	Pass	-
	16	Pass	-
	17	Pass	-
	18	Pass	-
	19	Pass	-
E	20	Pass	-
	21	Pass	-
	22	Pass	-
	23	No Access	-
F	24	No Access	-
	25	No Access	-
	26	Pass	-
	27	Pass	-
	28	Pass	-
	29	Pass	-
G	30	No Access	-
	31	Pass	-
	32	Pass	-
	33	Pass	-
	34	Pass	-
	35	Pass	-
H	36	Pass	-
	37	Pass	-
	38	No Access	-
	39	Pass	-
	40	Pass	-
	41	Pass	-

I	42	No Access	-
	43	Pass	-
	44	Pass	-
	45	Pass	-
J	46	Pass	-
	47	Pass	-
	48	Pass	-
	49	Pass	-
K	50	No Access	-
	51	No Access	-
	52	Pass	-
	53	Pass	-
L	54	Pass	-
	55	Pass	-
	56	Pass	-
	57	Pass	-
M	58	Pass	-
	59	Pass	-
	60	Pass	-
	61	Pass	-
N	62	Pass	-
	63	Pass	-
	64	Pass	-
	65	Pass	-
O	66	Pass	-
	67	Pass	-
	68	Pass	-
	69	Pass	-
Residents Lounge	-	Pass	-

* Values are only recorded if greater than 5mm/m

4.3 Original Documentation

The following plans were made available for this assessment and were used in calculations;

- Waimairi County Council – #1867/Pensioner Flats – Plan, Elevation, Section – 1969
- Waimairi County Council – #2187/Single Person Pensioner Flats – Plan, Elevation, Section – 1963
- Christchurch City Council - #93/94-292 – New Residents Lounge, Fletcher Place - Plans, Elevations, Details - 1994

Copies of design calculations were not available for the site assessment. A typical floor plan of the residential units and residents lounge has been produced by Opus from site measurements to help investigate potential critical structural weaknesses (CSWs) and identify details which required particular attention.

5 Damage

This section outlines the damage to the buildings that was observed during site visits. It is not intended to be a complete summary of the damage sustained by the buildings due to the earthquakes. Some forms of damage may not be able to be identified with a visual inspection only.

It is noted that none of the residential unit blocks, and individual units, have suffered any significant damage.

Note: Any photo referenced in this section can be found in Appendix A.

5.1 Residual Displacements

The results of the level survey indicate that no significant ground settlement has occurred due to the earthquakes.

5.2 Foundations

Foundation damage was limited to minimal cracking in the concrete foundation perimeter footing on some of the blocks.

5.3 Primary Gravity Structure

The roofline has been damaged between Unit 10 and 11, where a fire wall may have been subject to differential settlement and movement of the wall during earthquake actions (photo 15).

No damage was evident in the timber framing or roof structure of any other unit.

5.4 Primary Lateral-Resistance Structure

No damage to the primary lateral resistance structure.

5.5 Non Structural Elements

Minimal cracking of plasterboard ceiling diaphragms and wall linings was observed in the units. This form of damage is common throughout the units.

Minimal stepped cracking in the concrete block and brick veneer exterior cladding mortar joints was observed on some of the units.

5.6 General Observations

The buildings appeared to have performed reasonably well, as would be expected for buildings of this type, during the earthquakes. They have suffered distributed amounts of minor damage which is typical of the construction type and age of construction.

6 Detailed Seismic Assessment

The detailed seismic assessment has been based on the NZSEE 2006 [2] guidelines for the "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" together with the "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure" [3] draft document prepared by the Engineering Advisory Group on 19 July 2011, and the SESOC guidelines "Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes" [5] issued on 21 December 2011.

As the residential units have the same floor plan, the analysis was simplified by conducting the analysis of one multi-unit block with brick cladding and using this for all multi-unit blocks.

6.1 Critical Structural Weaknesses

The term Critical Structural Weakness (CSW) refers to a component of a building that could contribute to increased levels of damage or cause premature collapse of a building.

No CSWs were identified in the buildings.

6.2 Quantitative Assessment Methodology

The assessment assumptions and methodology have been included in Appendix B. A brief summary follows:

Hand calculations were performed to determine seismic forces from the current building codes. These forces were applied globally to the structure and the capacities of the walls were calculated and used to estimate the %NBS. The walls, highlighted in Figure 8 through to Figure 13, were used for bracing in their respective directions for their respective blocks.

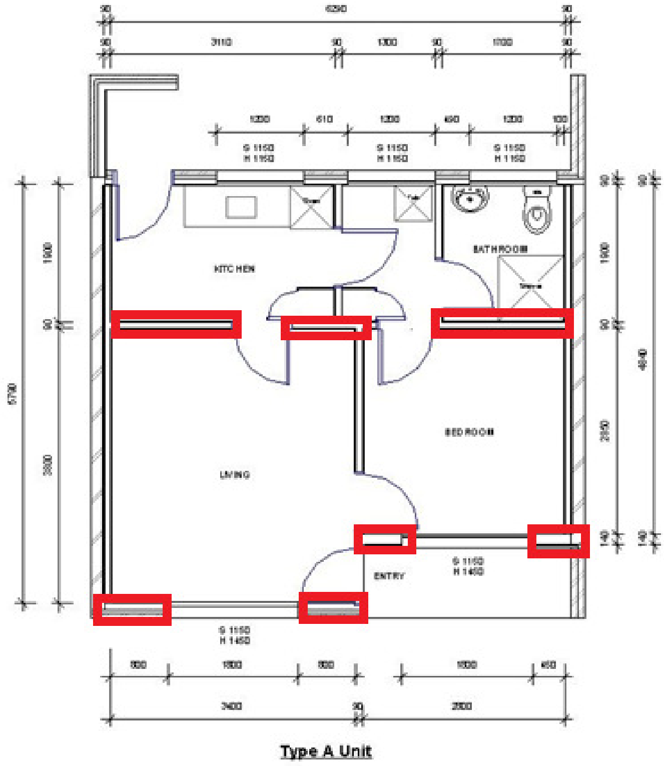


Figure 8: Walls in Type A blocks used for bracing in the longitudinal direction.

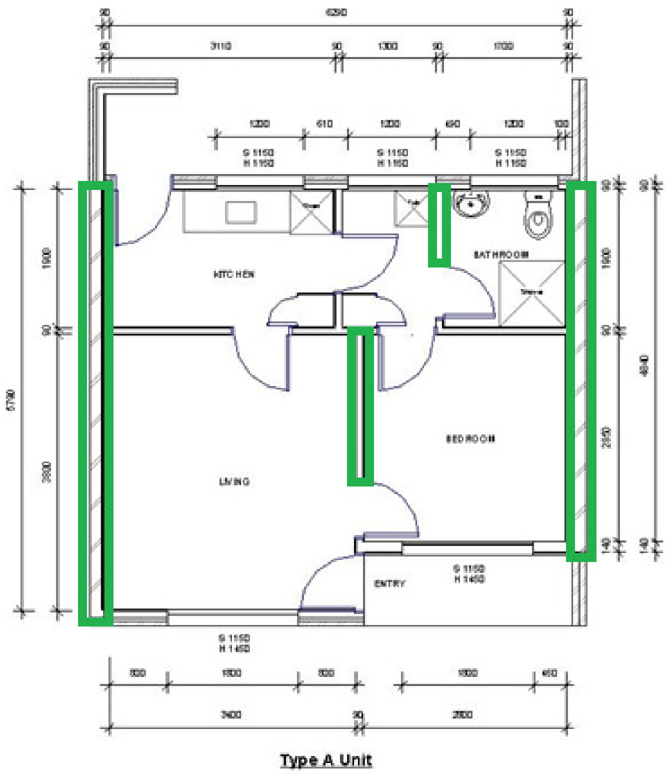


Figure 9: Walls in Type A blocks used for bracing in the transverse direction.

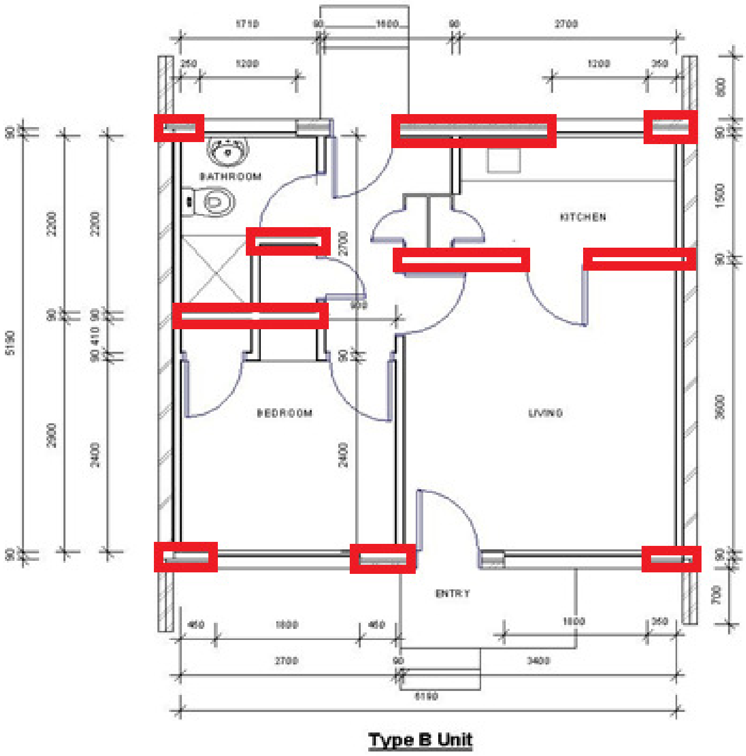


Figure 10: Walls in Type B blocks used for bracing in the longitudinal direction.

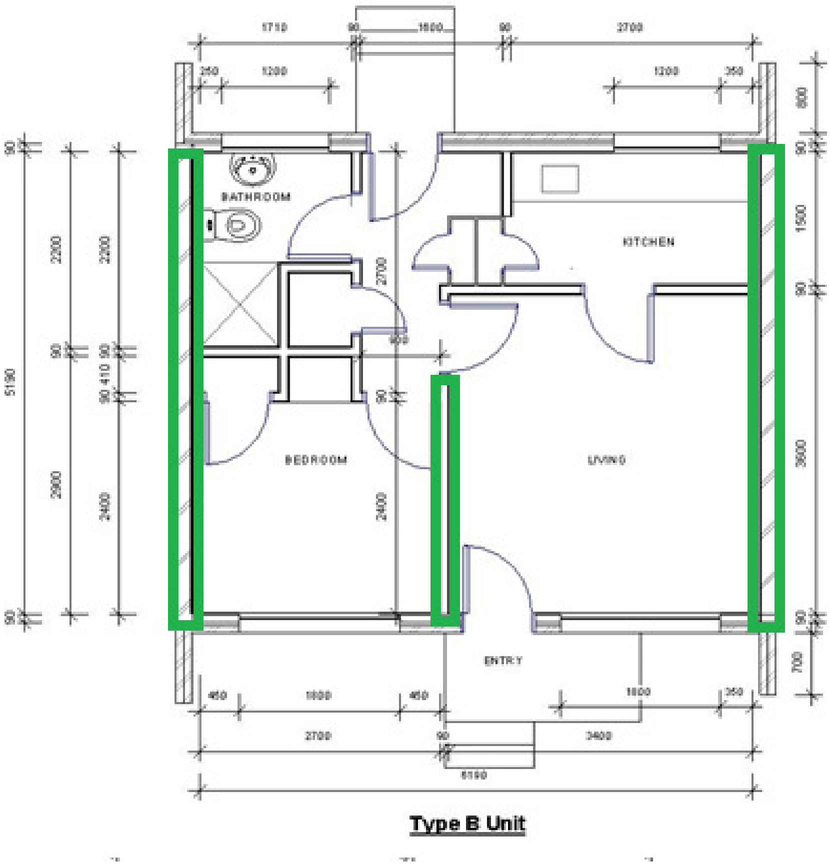


Figure 11: Walls in Type B blocks used for bracing in the transverse direction.

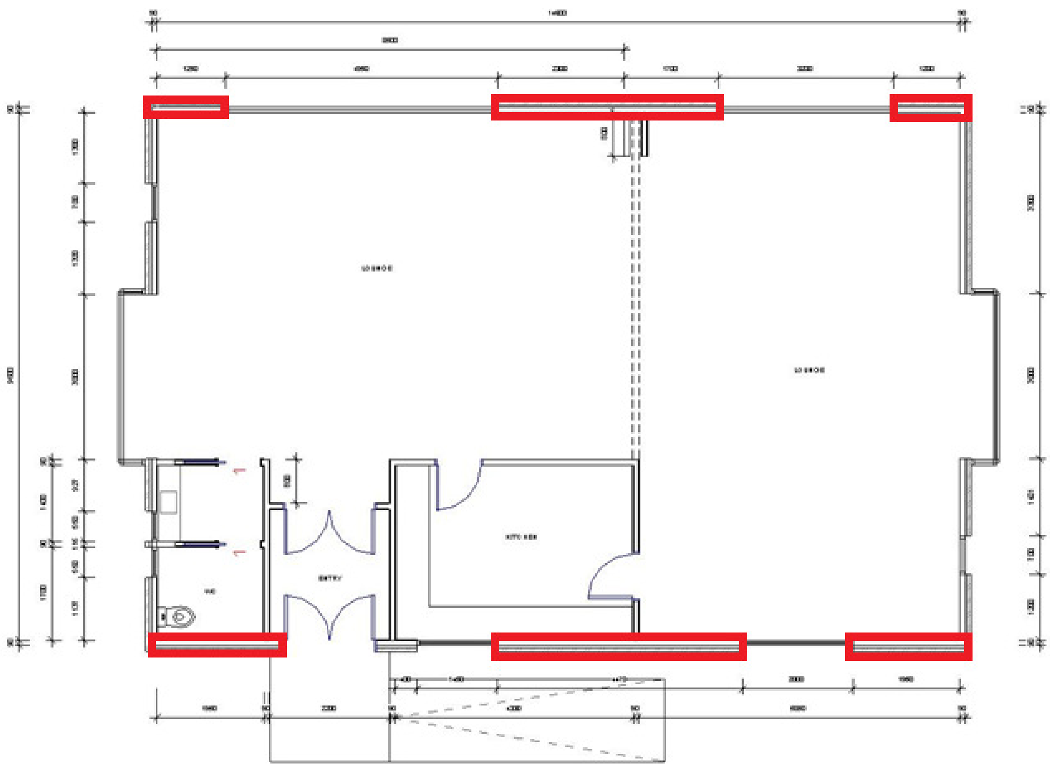


Figure 12: Walls in the resident's lounge used for bracing in the longitudinal direction.

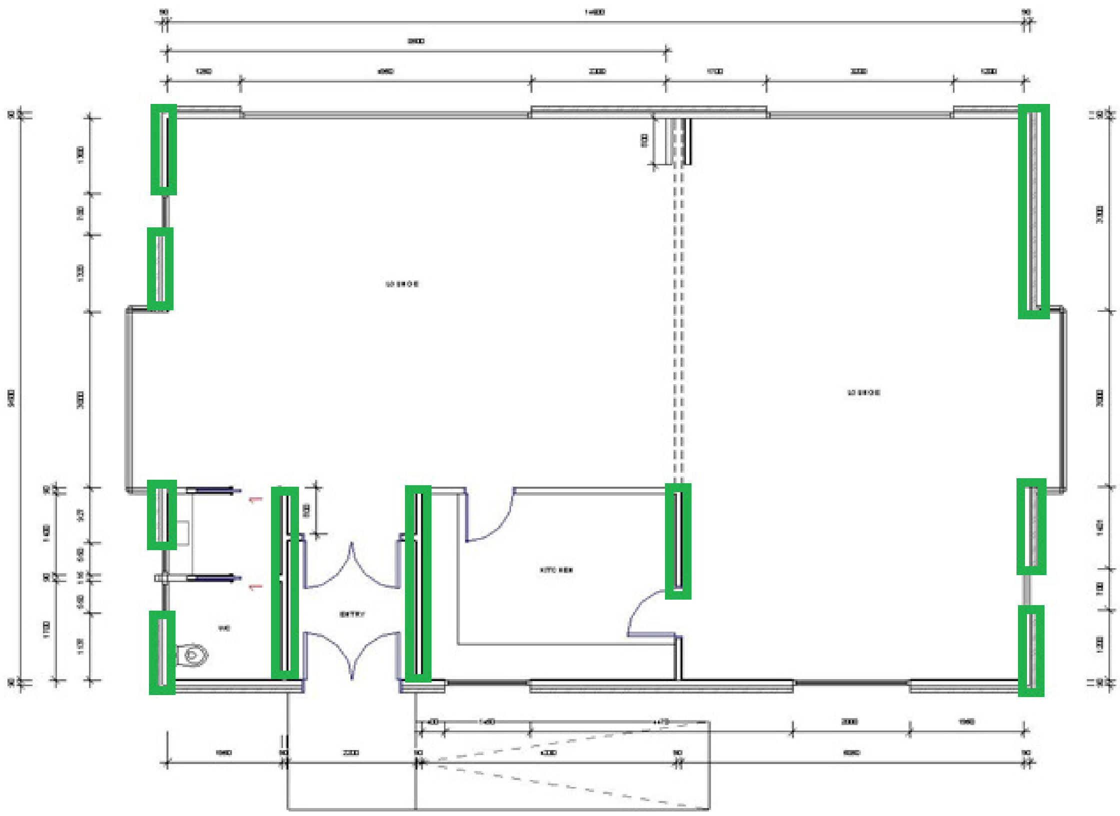


Figure 13: Walls in the residents lounge used for bracing in the transverse direction.

6.3 Limitations and Assumptions in Results

The observed level of damage suffered by the buildings was deemed low enough to not affect their capacity. Therefore the analysis and assessment of the buildings was based on them being in an undamaged state. There may have been damage to the buildings that was unable to be observed that could cause the capacity of the buildings to be reduced; therefore the current capacity of the buildings may be lower than that stated.

The results have been reported as a %NBS and the stated value is that obtained from our analysis and assessment. Despite the use of best national and international practice in this analysis and assessment, this value contains uncertainty due to the many assumptions and simplifications which are made during the assessment. These include:

- Simplifications made in the analysis, including boundary conditions such as foundation fixity.
- Assessments of material strengths based on limited drawings, specifications and site inspections.
- The normal variation in material properties which change from batch to batch.
- Approximations made in the assessment of the capacity of each element, especially when considering the post-yield behaviour.
- Construction is consistent with normal practise of the era in which constructed.

6.4 Assessment

A summary of the structural performance of the buildings is shown in Table 3. Note that the values given represent the worst performing elements in the building, where these effectively define the building's capacity. Other elements within the building may have significantly greater capacity when compared with the governing elements.

Table 3: Summary of Seismic Performance

Building Description	Critical element	% NBS based on calculated capacity in longitudinal direction	% NBS based on calculated capacity in transverse direction.
Type A Blocks	Bracing capacity of shear walls	54%	100%
Type B Blocks	Bracing capacity of shear walls	62%	100%
Residents Lounge	Bracing capacity of shear walls	100%	100%

7 Geotechnical Summary

CERA indicates that Fletcher Place is located in a TC1 zone (as shown in Figure 14. This classification suggests future significant earthquakes will cause minor to moderate land damage due to liquefaction and settlement.

Figure 14: CERA Technical Categories map (loc. starred).

There is no evidence to suggest that further geotechnical investigation is warranted for this site.

8 Conclusions

- None of the buildings on site are considered to be Earthquake Prone.
- The type A residential units have a capacity of 54% NBS, as limited by the in-plane capacity of the bracing walls. They are deemed to be a 'moderate risk' in a design seismic event according to NZSEE guidelines. Their level of risk is 5-10 times that of a 100% NBS building (Figure 1).
- The type B residential units have a capacity of 62% NBS, as limited by the in-plane capacity of the bracing walls. They are deemed to be a 'moderate risk' in a design seismic event according to NZSEE guidelines. Their level of risk is 5-10 times that of a 100% NBS building (Figure 1).
- The residents lounge has a capacity of 100% NBS, as limited by the in-plane capacity of the bracing walls. They are deemed to be a 'low risk' in a design seismic event according to NZSEE guidelines.
- Based on the geotechnical appraisal, differential settlement as a result of liquefaction could result in further damage, similar in nature to that which has occurred in the recent earthquake sequence. However, based on the nature of construction, this is unlikely to result in the collapse of concrete ground beams beneath the masonry walls.

9 Recommendations

It is recommended that;

- Strengthening schemes be developed to increase the seismic capacity of the residential units to at least 67%NBS.
- Veneer at height (gable ends) have the veneer ties checked.
- Cosmetic repairs be undertaken as required.

10 Limitations

- This report is based on an inspection of the buildings and focuses on the structural damage resulting from the Canterbury Earthquake sequence since September 2010. Some non-structural damage may be described but this is not intended to be a complete list of damage to non-structural items.
- Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time.
- This report is prepared for the Christchurch City Council to assist in the assessment of any remedial works required for the Fletcher Place Housing Complex. It is not intended for any other party or purpose.

11 References

[1] NZS 1170.5: 2004, Structural design actions, Part 5 Earthquake actions, Standards New Zealand.

[2] NZSEE (2006), Assessment and improvement of the structural performance of buildings in earthquakes, New Zealand Society for Earthquake Engineering.

[3] Engineering Advisory Group, Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure, Draft Prepared by the Engineering Advisory Group, Revision 5, 19 July 2011.

[4] Engineering Advisory Group, *Guidance on Detailed Engineering Evaluation of Non-residential buildings, Part 3 Technical Guidance*, Draft Prepared by the Engineering Advisory Group, 13 December 2011.

[5] SESOC (2011), Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes, Structural Engineering Society of New Zealand, 21 December 2011.

[6] MBIE (2012), Repairing and rebuilding houses affected by the Canterbury earthquakes, Ministry of Building, Innovation and Employment, December 2012.

Appendix A - Photographs

Fletcher Place Housing Complex		
No.	Item description	Photo
Residential Unit – Type A		
1.	Typical exterior elevation (front)	
2.	Typical exterior elevation (front)	

3.	Typical exterior elevation (end)	
4.	Typical change of alignment in units	
Residential Unit – Type B		
5.	Typical exterior elevation (end)	

6.	Typical exterior elevation (back)	
7.	Typical exterior elevation (front)	
8.	Typical ceiling void	

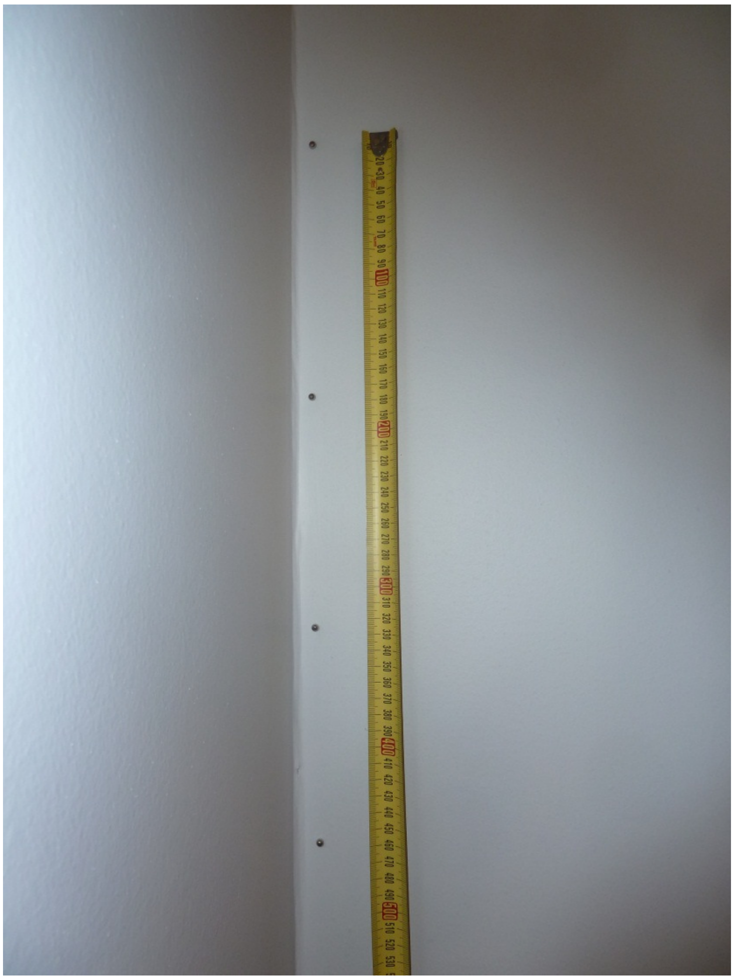
9.	Typical floor void	
Residential Units - Damage		
10.	Typical stepped cracking of block veneer	

11.	Typical cracking of brick veneer	
12.	Typical cracking of brick veneer	

13.	Typical cracking of gib linings	
14.	Typical spacing of interior lining fixings	

<table>
<tr><td>15.</td><td>The roofline between Unit 10 and 11 shows some upward movement along the line of the firewall</td><td></td></tr>
<tr><td colspan="3">Residents Lounge</td></tr>
<tr><td>16.</td><td>Typical exterior elevation (end)</td><td></td></tr>
<tr><td>17.</td><td>Typical exterior elevation (front)</td><td></td></tr>
</table>

18.	Typical exterior elevation (end)	
19.	Typical exterior elevation (back)	
20.	Typical cracking of brick veneer	

21.	Typical spacing of interior lining fixings	
22.	Interior	

23.	Interior	

Appendix B - Methodology and Assumptions

Seismic Parameters

As per NZS 1170.5:

- T < 0.4s (assumed)
- Soil: Category D
- Z = 0.3
- R = 1.0 (IL2, 50 year)
- N(T,D) = 1.0

For the analyses, a μ of 2 was assumed for the residential units.

Analysis Procedure

As the units are small and have a number of closely spaced walls in both directions, the fibrous plaster board ceilings are assumed to be capable of transferring loads to all walls. It was therefore assumed that a global method could be used to carry the forces down to ground level in each direction. Bracing capacities were found by assuming a certain kN/m rating for the walls along each line. Due to the relatively unknown nature of the walls, the kN/m rating was taken as 3 kN/m for all timber walls with an aspect ratio (height: length) of less than 2:1. This was scaled down to zero kN/m at an aspect ratio of 3.5:1 as per NZSEE guidelines. %NBS values were then found through the ratio of bracing demand to bracing capacity for all walls in each direction.

Additional Assumptions

Further assumptions about the seismic performance of the buildings were:

- Foundations and foundation connections had adequate capacity to resist and transfer earthquake loads.
- Connections between all elements of the lateral load resisting systems are detailed to adequately transfer their loads sufficiently and are strong enough so as to not fail before the lateral load resisting elements.

Appendix C – CERA DEE Spreadsheet

Detailed Engineering Evaluation Summary Data V1.14

Location

Building Name:	Fletcher Courts Type A	Reviewer:	Mary Ann Halliday
	Unit / No: / Street	CPEng No:	67073
Building Address:	Fletcher Place	Company:	Opus International Consultants
Legal Description:		Company project number:	6-QC340.00
		Company phone number:	
	Degrees / Min / Sec		
GPS south:	43 / 31 / 44.53	Date of submission:	13/11/2013
GPS east:	172 / 34 / 22.51	Inspection Date:	16/09/2013
		Revision:	Final
Building Unique Identifier (CCC):	PRO0230	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:	gravel	Soil Profile (if available):	
Site Class (to NZS1170.5):	C		
Proximity to waterway (m, if <100m):		If Ground improvement on site, describe:	
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):
Ground floor split?	no		Ground floor elevation above ground (m):
Storeys below ground	0		
Foundation type:	mat slab		if Foundation type is other, describe:
Building height (m):	5.00		height from ground to level of uppermost seismic mass (for IEP only) (m):
Floor footprint area (approx):	140		
Age of Building (years):	40		Date of design: 1965-1976
Strengthening present?	no		If so, when (year)?
			And what load level (%g)?
Use (ground floor):	multi-unit residential		Brief strengthening description:
Use (upper floors):			
Use notes (if required):			
Importance level (to NZS1170.5):	IL2		

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber framed	rafter type, purlin type and cladding	
Floors:	concrete flat slab	slab thickness (mm)	
Beams:	none	overall depth x width (mm x mm)	
Columns:			
Walls:	non-load bearing		0

Lateral load resisting structure

Lateral system along:	lightweight timber framed walls	**Note: Define along and across in detailed report!**	note typical wall length (m)	
Ductility assumed, μ:	2.00			
Period along:		0.00	estimate or calculation?	
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	lightweight timber framed walls		note typical wall length (m)	
Ductility assumed, μ:	2.00			
Period across:		0.00	estimate or calculation?	
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

north (mm):		leave blank if not relevant
east (mm):		
south (mm):		
west (mm):		

Non-structural elements

Stairs:			
Wall cladding:	brick or tile	describe (note cavity if exists)	
Roof Cladding:	Metal	describe	
Glazing:	aluminium frames		
Ceilings:	fibrous plaster, fixed		
Services(list):			

Available documentation

Architectural	partial	original designer name/date	
Structural	partial	original designer name/date	
Mechanical		original designer name/date	
Electrical		original designer name/date	
Geotech report	none	original designer name/date	

Damage

Site:
(refer DEE Table 4-2)

Site performance:		Describe damage:	
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:	green		
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:	0%		
	Describe (summary):			
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	no	Describe:	

$$Damage\_Ratio = \frac{(\%NBS\,(before) - \%NBS\,(after))}{\%NBS\,(before)}$$

Recommendations

	Level of repair/strengthening required:		Describe:	
	Building Consent required:		Describe:	
	Interim occupancy recommendations:		Describe:	
Along	Assessed %NBS before e'quakes:	100%	##### %NBS from IEP below	If IEP not used, please detail assessment methodology: Equivalent Static
	Assessed %NBS after e'quakes:	100%		
Across	Assessed %NBS before e'quakes:	54%	##### %NBS from IEP below	
	Assessed %NBS after e'quakes:	54%		

Detailed Engineering Evaluation Summary Data V1.14

Location

Building Name:	Fletcher Courts Type B	Reviewer:	Mary Ann Halliday
	Unit / No: / Street	CPEng No:	67073
Building Address:	Fletcher Place	Company:	Opus International Consultants
Legal Description:		Company project number:	6-QC340.00
		Company phone number:	
	Degrees / Min / Sec		
GPS south:	43 / 31 / 44.53	Date of submission:	13/11/2013
GPS east:	172 / 34 / 22.51	Inspection Date:	16/09/2013
		Revision:	Final
Building Unique Identifier (CCC):	PRO0230	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:	gravel	Soil Profile (if available):	
Site Class (to NZS1170.5):	C		
Proximity to waterway (m, if <100m):		If Ground improvement on site, describe:	
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	

Building

No. of storeys above ground:	1	single storey = 1	
		Ground floor elevation (Absolute) (m):	
Ground floor split?	no	Ground floor elevation above ground (m):	
Storeys below ground	0		
Foundation type:	isolated pads, no tie beams	if Foundation type is other, describe:	
Building height (m):	5.00	height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	140		
Age of Building (years):	40	Date of design:	1965-1976
Strengthening present?	no	If so, when (year)?	
		And what load level (%g)?	
Use (ground floor):	multi-unit residential	Brief strengthening description:	
Use (upper floors):			
Use notes (if required):			
Importance level (to NZS1170.5):	IL2		

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber framed	rafter type, purlin type and cladding	
Floors:	timber	joist depth and spacing (mm)	
Beams:	none	overall depth x width (mm x mm)	
Columns:			
Walls:	non-load bearing		0

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	lightweight timber framed walls		note typical wall length (m)	
Ductility assumed, μ:	2.00			
Period along:		0.00	estimate or calculation?	
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	lightweight timber framed walls		note typical wall length (m)	
Ductility assumed, μ:	2.00			
Period across:		0.00	estimate or calculation?	
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

north (mm):		leave blank if not relevant
east (mm):		
south (mm):		
west (mm):		

Non-structural elements

Stairs:			
Wall cladding:	brick or tile	describe (note cavity if exists)	
Roof Cladding:	Metal	describe	
Glazing:	aluminium frames		
Ceilings:	fibrous plaster, fixed		
Services(list):			

Available documentation

Architectural	partial	original designer name/date	
Structural	partial	original designer name/date	
Mechanical		original designer name/date	
Electrical		original designer name/date	
Geotech report	none	original designer name/date	

Damage

Site:
(refer DEE Table 4-2)

Site performance:		Describe damage:	
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:	green		
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:	0%		
	Describe (summary):			
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	no	Describe:	

$$Damage\_Ratio = \frac{(\%NBS\,(before) - \%NBS\,(after))}{\%NBS\,(before)}$$

Recommendations

	Level of repair/strengthening required:		Describe:	
	Building Consent required:		Describe:	
	Interim occupancy recommendations:		Describe:	
Along	Assessed %NBS before e'quakes:	100%	##### %NBS from IEP below	If IEP not used, please detail assessment methodology: Equivalent Static
	Assessed %NBS after e'quakes:	100%		
Across	Assessed %NBS before e'quakes:	62%	##### %NBS from IEP below	
	Assessed %NBS after e'quakes:	62%		

Detailed Engineering Evaluation Summary Data V1.14

Location

Building Name:	Fletcher Courts Residents Lounge	Reviewer:	Mary Ann Halliday
Building Address:	Unit: No: Street: Fletcher Place	CPEng No:	67073
Legal Description:		Company:	Opus International Consultants
		Company project number:	6-QC340.00
		Company phone number:	
GPS south:	Degrees 43, Min 31, Sec 44.53	Date of submission:	13/11/2013
GPS east:	Degrees 172, Min 34, Sec 22.51	Inspection Date:	16/09/2013
		Revision:	Final
Building Unique Identifier (CCC):	PRO0230	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:	gravel	Soil Profile (if available):	
Site Class (to NZS1170.5):	C		
Proximity to waterway (m, if <100m):		If Ground improvement on site, describe:	
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	
Ground floor split?	no		Ground floor elevation above ground (m):	
Storeys below ground	0			
Foundation type:	strip footings		if Foundation type is other, describe:	
Building height (m):	5.00		height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	126			
Age of Building (years):	19		Date of design:	1992-2004
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	multi-unit residential		Brief strengthening description:	
Use (upper floors):				
Use notes (if required):				
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber framed	rafter type, purlin type and cladding	
Floors:	concrete flat slab	slab thickness (mm)	
Beams:	none	overall depth x width (mm x mm)	
Columns:			
Walls:	non-load bearing	0	

Lateral load resisting structure

Lateral system along:	lightweight timber framed walls	**Note: Define along and across in detailed report!**	note typical wall length (m)	
Ductility assumed, μ:	2.00			
Period along:		0.00	estimate or calculation?	
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	lightweight timber framed walls		note typical wall length (m)	
Ductility assumed, μ:	2.00			
Period across:		0.00	estimate or calculation?	
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

north (mm):		leave blank if not relevant
east (mm):		
south (mm):		
west (mm):		

Non-structural elements

Stairs:			
Wall cladding:	brick or tile	describe (note cavity if exists)	
Roof Cladding:	Metal	describe	
Glazing:	aluminium frames		
Ceilings:	fibrous plaster, fixed		
Services(list):			

Available documentation

Architectural	partial	original designer name/date	
Structural	partial	original designer name/date	
Mechanical		original designer name/date	
Electrical		original designer name/date	
Geotech report	none	original designer name/date	

Damage

Site:
(refer DEE Table 4-2)

Site performance:		Describe damage:	
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:	green		
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:	0%		
	Describe (summary):			
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	no	Describe:	

$$Damage\_Ratio = \frac{(\%NBS\,(before) - \%NBS\,(after))}{\%NBS\,(before)}$$

Recommendations

	Level of repair/strengthening required:		Describe:	
	Building Consent required:		Describe:	
	Interim occupancy recommendations:		Describe:	
Along	Assessed %NBS before e'quakes:	100% ##### %NBS from IEP below	If IEP not used, please detail assessment methodology:	Equivalent Static
	Assessed %NBS after e'quakes:	100%		
Across	Assessed %NBS before e'quakes:	100% ##### %NBS from IEP below		
	Assessed %NBS after e'quakes:	100%		

Opus International Consultants Ltd
20 Moorhouse Avenue
PO Box 1482, Christchurch Mail Centre,
Christchurch 8140
New Zealand

t: +64 3 363 5400
f: +64 3 365 7858
w: www.opus.co.nz