Christchurch City Council

Waltham Courts Housing Complex PRO 1049

Detailed Engineering Evaluation

Quantitative Assessment Report

Christchurch City Council

Waltham Courts Housing Complex

Quantitative Assessment Report

180 Waltham Road, Waltham,

Prepared By
Andrew Sawers
Building Technologist

Reviewed By
Lachlan Howat
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: March 2014
Reference: 6-QC414.00
Status: Final

Summary

Waltham Courts Housing Complex
PRO 1049

Detailed Engineering Evaluation
Quantitative Report - Summary
Final

Background

This is a summary of the quantitative report for the Waltham Courts 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 26 residential units on the site.

Key Damage Observed

The residential units have suffered minor to moderate damage to structural and non-structural elements. This included cracking of the paths around the complex and varying levels of damage to interior linings in all units. Some units suffered notably more damage than other units particularly Units 14 and 22. Pile damage was observed in Unit 14 and water damage was observed in the ceilings of various units. This damage was deemed low enough to not affect the capacities of the buildings.

Level Survey

All floor slopes were assessed in a laser level survey. Some of the floor slopes were greater than the 5mm/m limitation set out in the MBIE guidelines [6], as shown below.

Internal Lining Nail Spacings

The internal lining nail spacings were measured on site to vary between 200 - 350mm.

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	Nail Spacings
PRO 1049 B001 (Block A)	20-30%	Fail	Pass
PRO 1049 B002 (Block B)	20-30%	Fail	Pass
PRO 1049 B003 (Block C)	20-30%	Fail	Pass
PRO 1049 B004 (Block D)	20-30%	Fail	Pass
PRO 1049 B005 (Block E)	20-30%	Pass	Pass
PRO 1049 B006 (Block F)	20-30%	Pass	Pass
PRO 1049 B007 (Block G)	20-30%	Pass	Pass

PRO 1049B008 (Block H)	20-30%	Fail	Pass
PRO 1049 B009 (Block I)	20-30%	Pass	Pass

The super structures of the residential units have capacities 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.

The sub floor bracing in the residential units is 20-30% NBS as there is little evidence of adequate bracing and no evidence of a connection between the piles and the bearers. This failure mode is not a critical structural weakness as it will not cause a brittle failure. In the event of a significant seismic event, the units could come off their piles but the structures would not collapse. On this basis, the units still remain fit to occupy.

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

Recommendations

It is recommended that;

- Cosmetic repairs be undertaken as required, including replacing and repairing damaged linings.
- Sub floor bracing be installed to increase the capacity of this element to at least 67% NBS. This should include securing the bearers to the piles.
- Repair sunken pile on Unit 14 and investigate source of failure (adjacent stormwater drain).
- Water-tightness of roof structure be investigated.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council to undertake a detailed seismic assessment of the Waltham Courts Housing Complex, located at 180 Waltham Road, Waltham, following the Canterbury earthquake sequence since September 2010. The site was visited by Opus International Consultants on 11 November and 6 December 2013.

The purpose of the assessment is to determine if the buildings in the complex 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	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 26 residential units which were constructed in 1974. A site plan showing the location of the units, numbered 1 to 26, 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 two or four units.

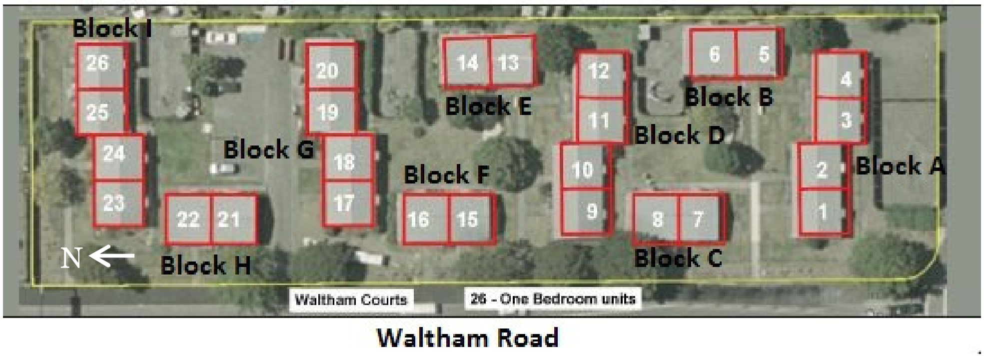


Figure 2: Site plan of Waltham Courts Housing Complex.

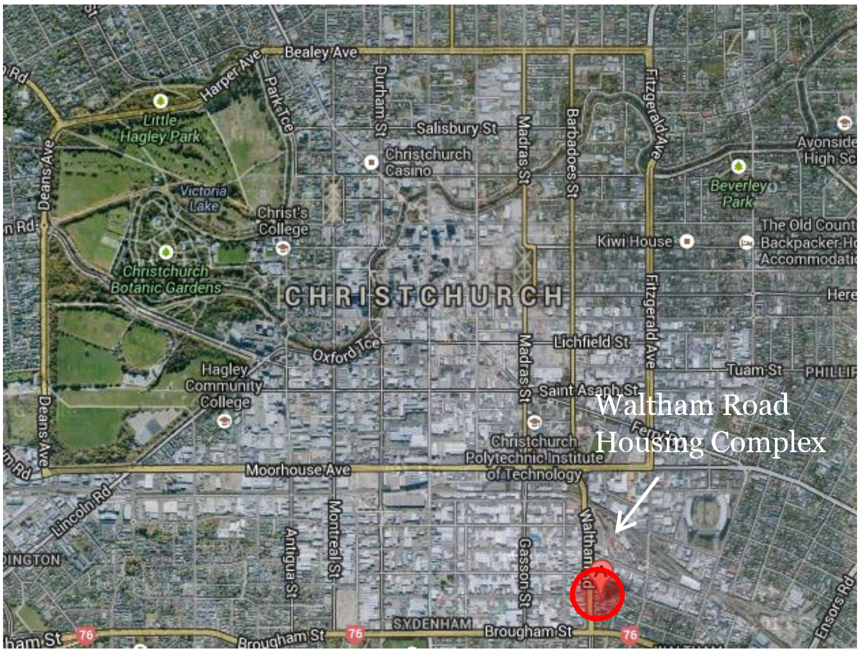


Figure 3: Location of Waltham Courts (circled) relative to Christchurch City CBD (Source: Google Earth).

The residential units are timber-framed buildings with diagonal timber braces. The roof structure comprises of timber roof trusses supporting lightweight metal roofs. The walls and ceilings are lined with 9.5mm plasterboard. External walls are clad with lightweight Hardiplank boards. The timber floor is supported on ordinary concrete piles, it was noted on site that the bearers were not tied to the piles. The perimeter of the sub-floor is clad with a render over mesh to give the appearance of a concrete perimeter wall.

Blocks with two units are separated by a timber framed fire wall with two layers of GIB Fyreline to both sides. A block work fire wall separates the two central units within blocks of four units.

Figure 4 shows a typical floor plan of a residential unit produced from site measurements by Opus. Figure 5 shows a cross section used in calculations.

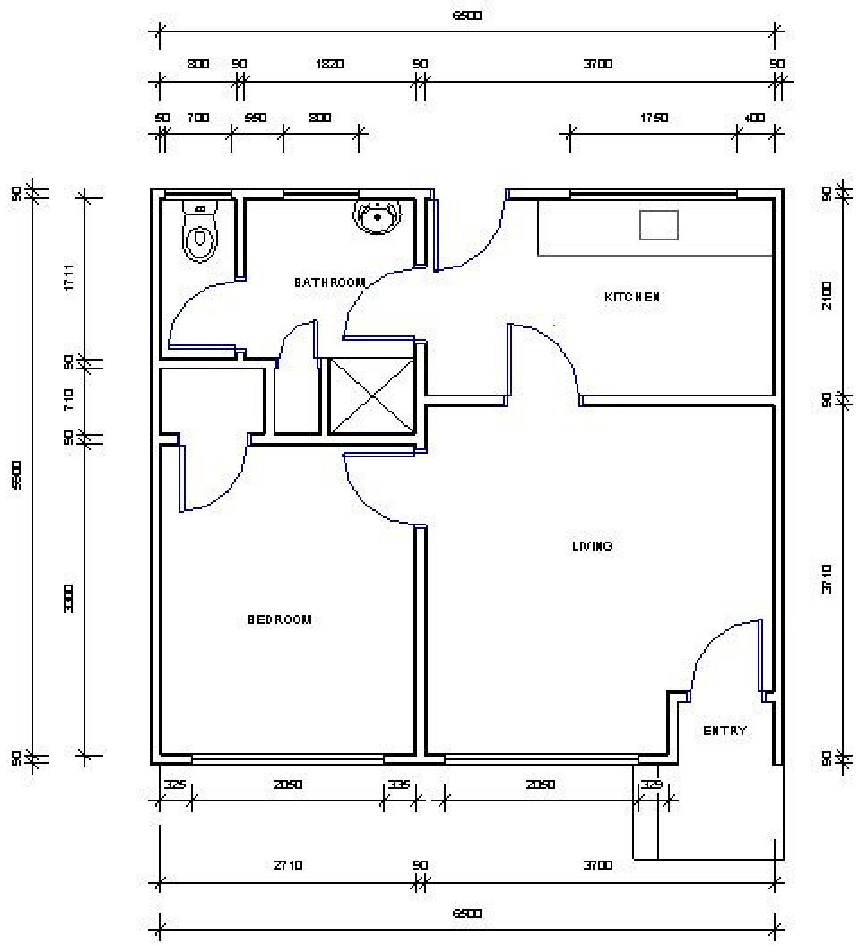


Figure 4: Typical partial floor plan of residential unit blocks.

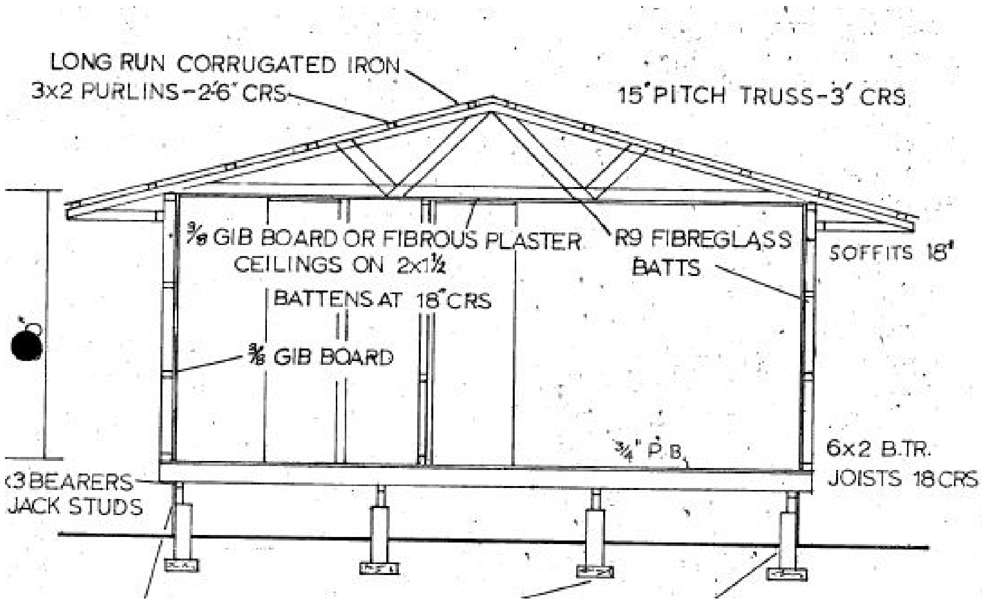


Figure 5: Cross section of Waltham Courts.

4.2 Survey

4.2.1 Post 22 February 2011 Rapid Assessment

A structural (Level 2) assessment of the buildings/property was undertaken on 9 March 2011 by Opus International Consultants.

4.2.2 Level Survey

A full level survey was not deemed to be necessary at Waltham Courts as it is located in a TC2 zone. Properties in TC2 zones suffered minor to moderate 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, the maximum slope in a unit was 12 mm/m (which exceeds the 5mm/m limitation imposed by MBIE guidelines).

Table 2: Summary of the Level Survey

Block	Unit No.	Comment	Maximum Fall*
A	1	Fail	6 mm/m
	2	Fail	6 mm/m
	3	Fail	7 mm/m
	4	Fail	10 mm/m
B	5	Fail	7 mm/m
	6	Pass	-
C	7	Fail	10 mm/m
	8	Pass	-
D	9	Pass	-
	10	Fail	12 mm/m
	11	Pass	-
	12	Pass	-
E	13	Pass	-
	14	Pass	-
F	15	Pass	-
	16	Pass	-
G	17	Pass	-
	18	Pass	-
	19	Pass	-
	20	Pass	-
H	21	Fail	9 mm/m
	22	Fail	6 mm/m
I	23	Pass	-
	24	Pass	-
	25	Pass	-
	26	Pass	-

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

Orange results represent floor levels which fall outside the MBIE guidelines when using the laser level but may comply when surveyed using more accurate equipment.

4.2.3 Nail Spacings

The internal lining nail spacings were measured on site to vary between 200 - 600mm.

4.3 Original Documentation

The following documentation was provided by the Christchurch City Council:

- 409 – Christchurch City Council – Keith Hay Homes Construction Drawings - 1974.
- A285 – Christchurch City Council – Fire Protection Details in Keith Hay Homes for Elderly Persons Housing – Pg. 1-2/2 – Plan; Section; Detail; Cross section; Elevation – 1974.
- A220 – Christchurch City Council – Proposed Elderly Persons Housing Waltham Road – Pg. 5/Unknown – Preliminary sketch plan – Undated.

In addition, a typical floor plan has been produced by Opus to help confirm as-built measurements.

Copies of the design calculations were not provided.

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 some residential unit blocks, and individual units, have suffered more damage than others. Overall, units closest to Brougham Street and Units 14 and 22 appear to have suffered the highest levels of damage.

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

5.1 Residual Displacements

Moderate displacements were observed in all units inspected. Several of the units showed displacements greater than the 5mm/m MBIE guideline, particularly Blocks A, B, C, D and H which showed significant displacements outside of the guidelines.

5.2 Foundations

A 140mm separation was observed between the timber floor bearer and the corner concrete pile of Unit 14 (photo 23). The render on mesh 'perimeter wall' has also sunk significantly along with the stormwater drain which drains directly below the corner pile (photos 21 and 22). The evidence on site shows that the settlement is likely due to a leak or inadequate path for water from this drain.

5.3 Primary Gravity Structure

There was no damage observed to the primary gravity structure.

5.4 Primary Lateral-Resistance Structure

Minor to moderate damage was observed to the primary lateral resistance structure in the form of cracking to plasterboard wall linings (photos 14 and 15) and ceiling diaphragms (photo 19). There is no evidence of sub floor bracing.

5.5 Non Structural Elements

Minor to moderate damage was observed to non-structural elements. Severe cracking to wall linings was observed from the window in the laundry of unit 22 (photo 16). Many doors were observed to be out of alignment (photo 18) and would not shut properly. Cracking was also observed in most units were interior wall and ceiling linings have separated, particularly in corners. Water damage was observed to the ceiling diaphragms in a number of units (photo 20). This damage suggests that the waterproofing of the roof structure may be compromised. This damage is deemed minor and does not affect the seismic capacity of the lateral-resistance structure.

Damage was also observed to the paths around the complex in the form of cracking and displacement.

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 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 similar 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 C. 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 6 and Figure 7, were used for bracing in their respective directions.

The piles are not attached to the foundations. Some of these piles are now not load bearing so cannot transfer forces in friction. The sub-floor height is low but there is potential for the buildings to slide off their foundations hence the sub-floor has been given a rating of 23-30%NBS. Actual numbers will depend upon the number of piles that have sunk within a building. Due to the low height of the potential drop it is not considered likely to cause collapse of the super structure.

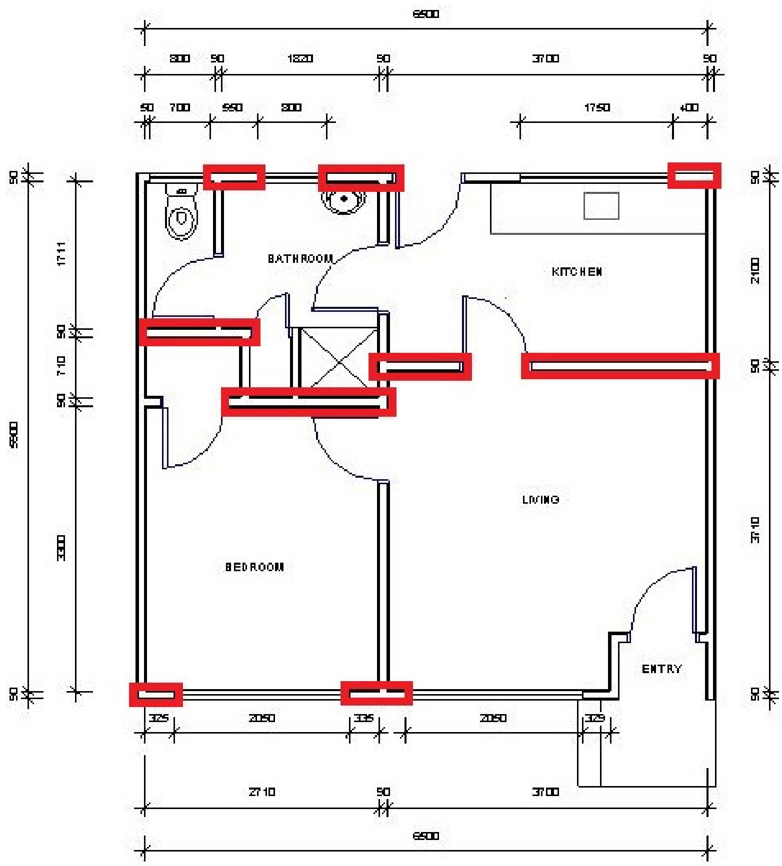


Figure 6: Walls used for bracing in the longitudinal direction.

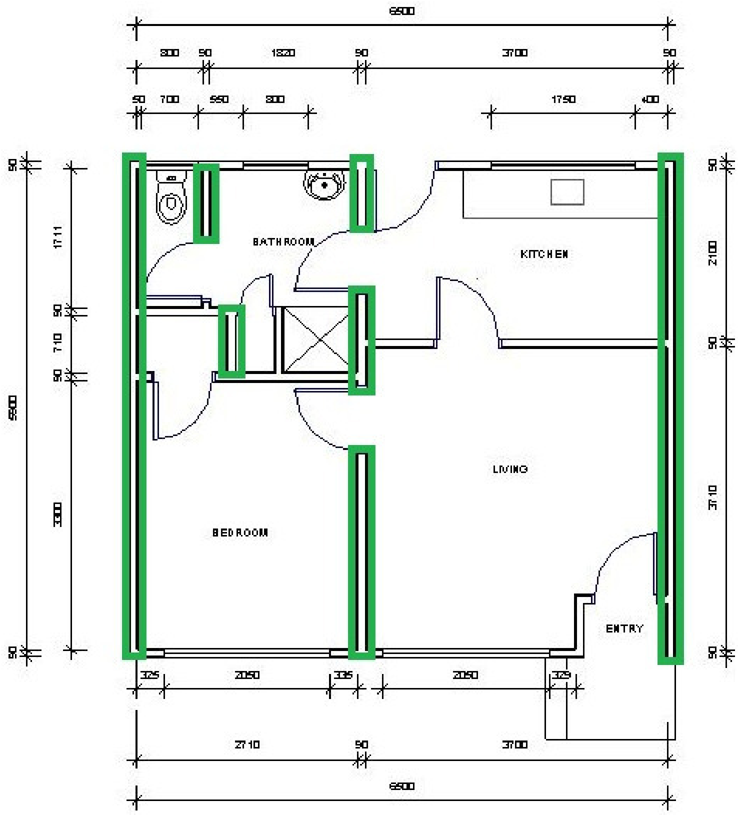


Figure 7: Walls used for bracing in the transverse direction.

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.
Blocks A - I	Timber bracing walls-	100%	100%
	Sub floor bracing	20-30%	20-30%

7 Geotechnical Summary

CERA indicates that Waltham Courts is located in a TC2 zone (as shown in Figure 8). This classification suggests future significant earthquakes will cause minor to moderate land damage due to liquefaction and settlement. However the site is across the road from a TC3 zone. This is consistent with increase in land damage at this end of the complex.

Figure 8: CERA Technical Categories map (loc. starred).

There is no evidence to suggest that further geotechnical investigation is warranted for this site given the light weight form of construction of the buildings.

8 Conclusions

- The super structures of the residential units have capacities 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. Their level of risk is less than 1 times that of a new building (Figure 1).
- The sub floor bracing in the residential units is 20-30% NBS as there is little evidence of adequate bracing and no evidence of a connection between the piles and the bearers. This failure mode is not a critical structural weakness as it will not cause a brittle failure. In the event of a significant seismic event, the units could come off their piles but the structures would not collapse. On this basis, the units still remain fit to occupy.
- Water damage to the ceilings indicates that the water-tightness of the roof may be compromised.

9 Recommendations

It is recommended that;

- Cosmetic repairs be undertaken as required, including replacing and repairing damaged linings.
- Sub floor bracing be installed to increase the capacity of this element to at least 67% NBS. This should include securing the bearers to the piles.
- Repair sunken pile on Unit 14 and investigate source of failure (adjacent stormwater drain).
- Water-tightness of roof structure be investigated.

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 Waltham Courts 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

Waltham Courts Housing Complex		
Residential Units Layout		
1.	Site view	
2.	2 Unit Block: Typical exterior elevation (front)	

3.	Typical exterior elevation (front)	
4.	4 unit block: Typical exterior elevation (front)	
5.	4 unit block: Typical block work fire wall separating units 2 and 3 within a block of 4 units	

6.	Typical ceiling space	
7.	Typical floor void	
8.	Typical bedroom	

9.	Typical laundry	
10.	Typical kitchen	
11.	Typical lounge	

12.	Nail spacings (200 – 300 mm)	
13.	Nail spacings (500 – 600 mm)	

14.	Typical cracking from corners of windows and doors	
15.	Typical cracking observed around windows and doors	

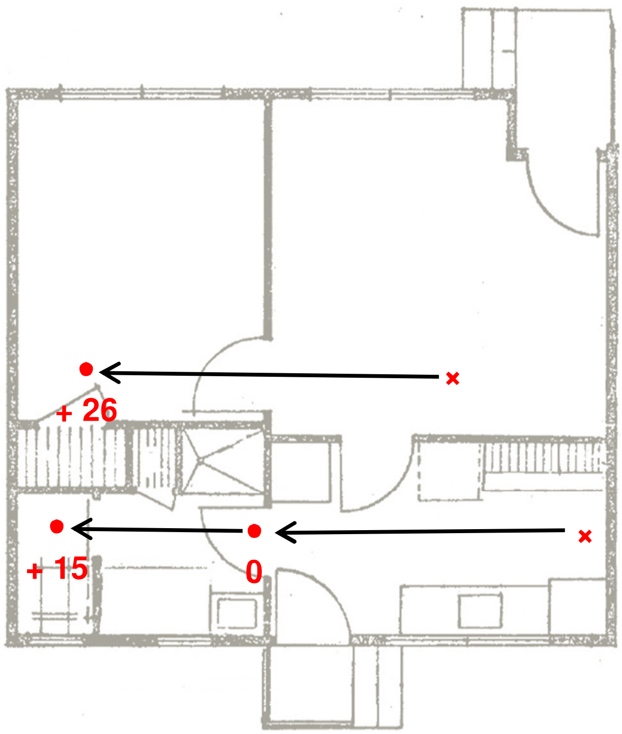
16.	Damage to particle board wall linings in laundry Unit 22	
17.	Typical cracking at corners between wall and ceiling linings	

18.	Doors out of alignment	
19.	Typical damage to ceiling diaphragms	
20.	Typical ceiling damage observed in most units (likely the result of water damage)	

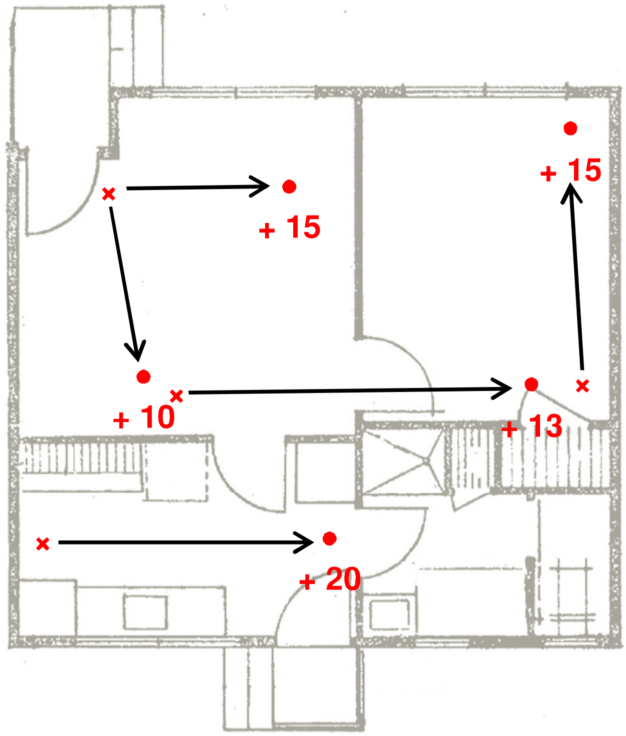
21.	Damage to sunken render and pile on the corner of Unit 14	
22.	Damage to sunken render and pile on the corner of Unit 14	

23.	Pile on the corner of Unit 14 sunk up to 140mm	

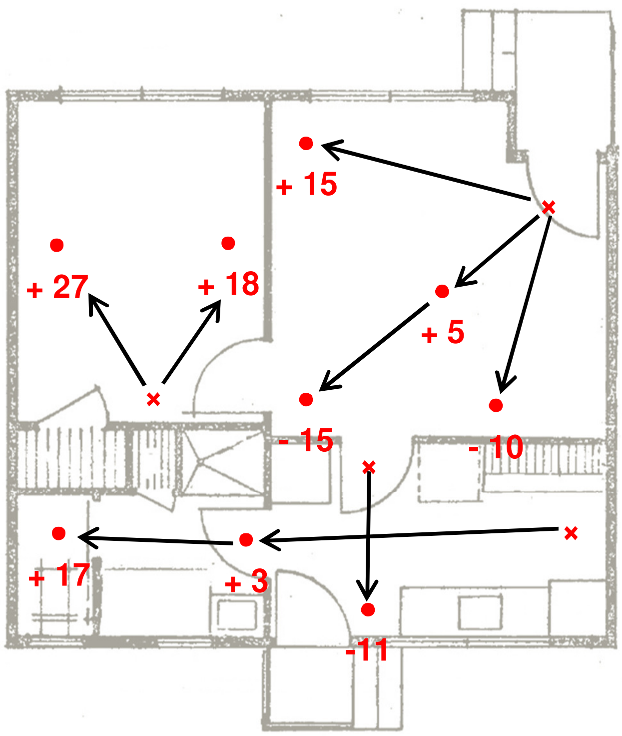
Appendix B – Level Survey



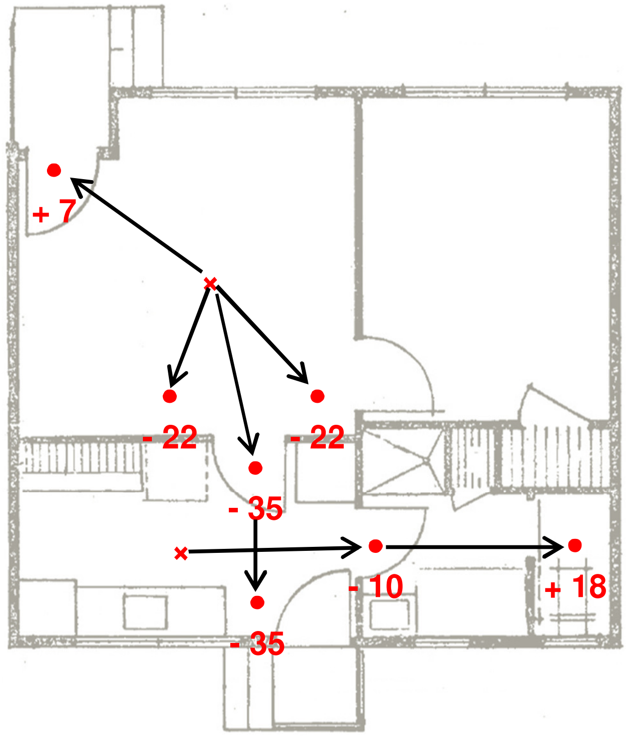
Unit 1



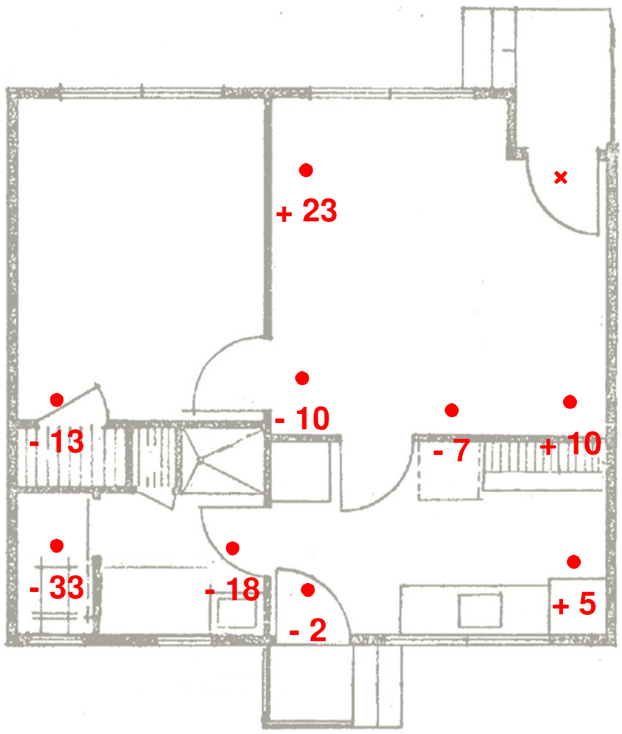
Unit 2



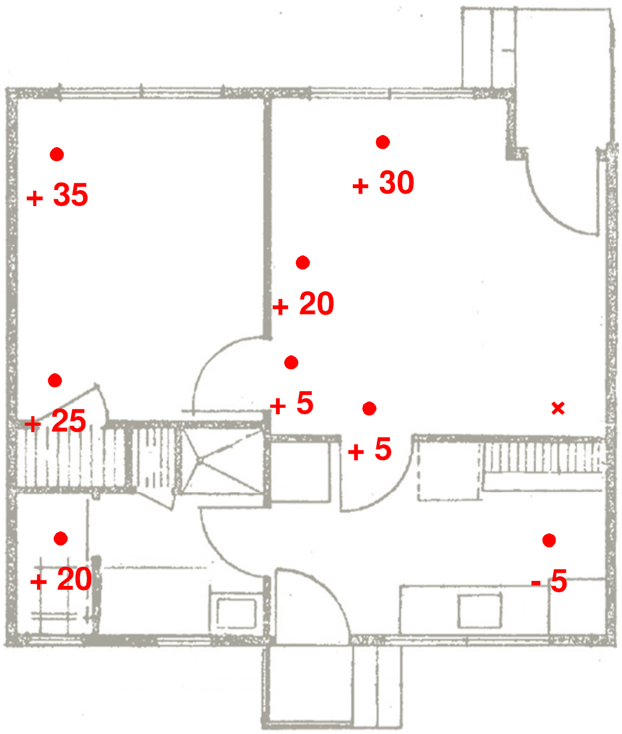
Unit 3



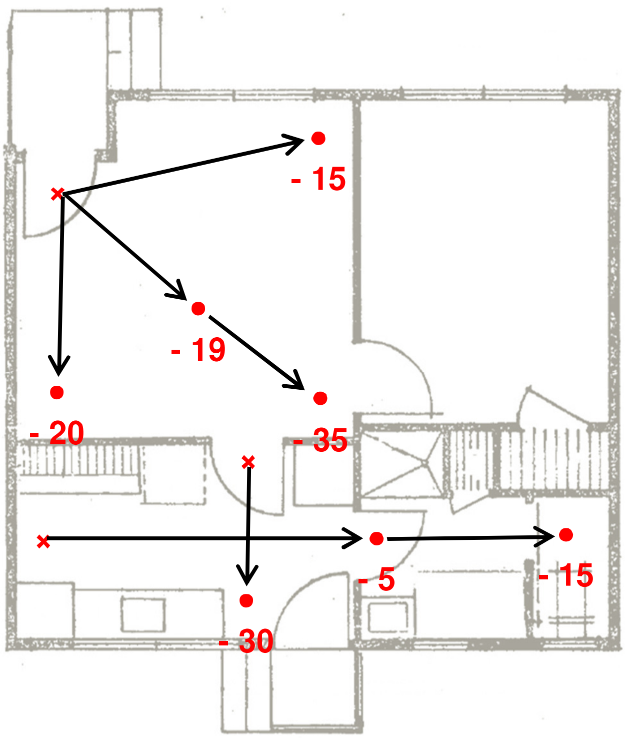
Unit 4



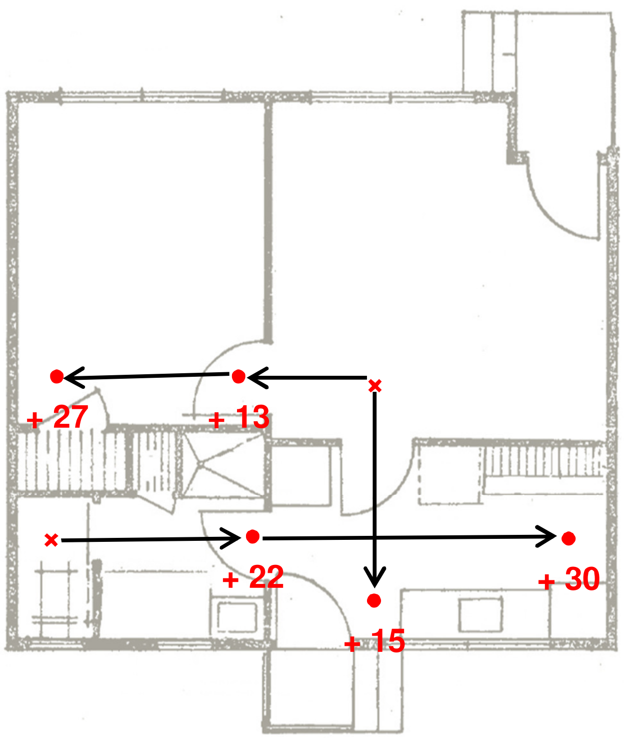
Unit 5



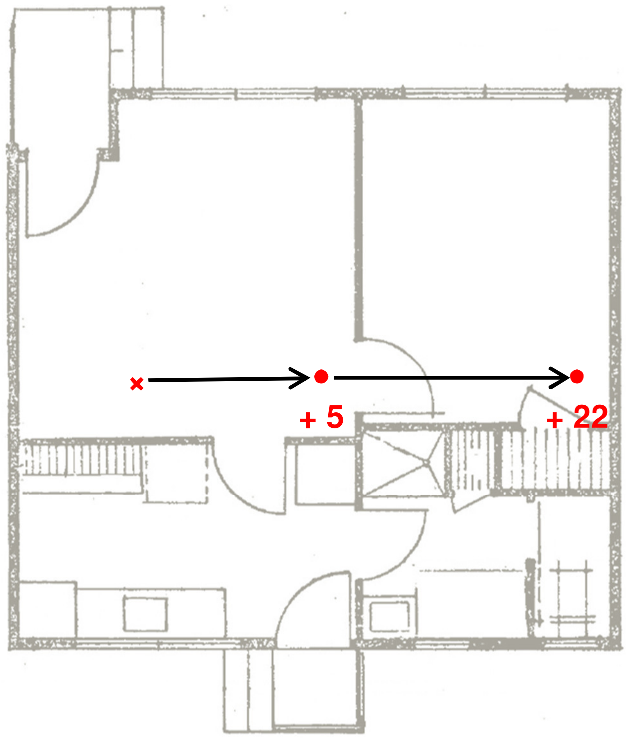
Unit 7



Unit 10



Unit 21



Unit 22

Appendix C – 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 D – CERA DEE Spreadsheet

Detailed Engineering Evaluation Summary Data V1.14

Location

Building Name:	Waltham Courts Housing Complex	Reviewer:	Mary Ann Halliday
	Unit / No: 180 / Street: Waltham	CPEng No:	67073
Building Address:	180 Waltham	Company:	Opus International Consultants
Legal Description:		Company project number:	6QC414.00
		Company phone number:	
GPS south:	Degrees 43, Min 32, Sec 48.48	Date of submission:	
GPS east:	Degrees 172, Min 38, Sec 51.01	Inspection Date:	11.11.13
		Revision:	1
Building Unique Identifier (CCC):	PRO1049	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:		Soil Profile (if available):	
Site Class (to NZS1170.5):	D		
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 split?	no	Ground floor elevation (Absolute) (m):	
Storeys below ground	0	Ground floor elevation above ground (m):	
Foundation type:	isolated pads, no tie beams	If Foundation type is other, describe:	
Building height (m):	3.00	height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	146		
Age of Building (years):	39	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:	frame system		
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:	timber	typical dimensions (mm x mm)	
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:	0.10	0.00	estimate or calculation?	estimated
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:	0.10	0.00	estimate or calculation?	estimated
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:	other light	describe	
Roof Cladding:	Metal	describe	
Glazing:	aluminium frames		
Ceilings:	strapped or direct fixed		
Services(list):			

Available documentation

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

Damage

Site:
(refer DEE Table 4-2)

Site performance:	Good	Describe damage:	
Settlement:	none observed	notes (if applicable):	
Differential settlement:	1:250-1:150	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:	slight	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?:		Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	yes	Describe:	

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

Recommendations

	Level of repair/strengthening required:	minor non-structural	Describe:	
	Building Consent required:	no	Describe:	
	Interim occupancy recommendations:	full occupancy	Describe:	
Along	Assessed %NBS before e'quakes:	20%	##### %NBS from IEP below	If IEP not used, please detail assessment methodology: equivalent static
	Assessed %NBS after e'quakes:	20%		
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