Christchurch City Council

Marwick Place Housing Complex PRO 0442

Detailed Engineering Evaluation

Quantitative Assessment Report

Christchurch City Council

Marwick Place Housing Complex

Quantitative Assessment Report

53 Daniels Road, Papanui, Christchurch, 8051

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Summary

Marwick Place Housing Complex
PRO 0442

Detailed Engineering Evaluation
Quantitative Report - Summary
Final

Background
This is a summary of the quantitative report for the Marwick 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 26 residential units on the site.

Key Damage Observed
The residential units have suffered moderate damage to non-structural elements. This included cracking of the veneer cladding due to settlement of the concrete pad foundations and shear cracking. There is also severe cracking to the concrete foundation perimeter footing in one residential unit blocks.

Level Survey
All floor slopes were assessed in a laser level survey. 10 of 27 units were observed to have floor slopes exceeding 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 150-450mm.

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%	Indicative Floor Levels	Nail Spacings
PRO 0442 B001 (Block A)	59%	Fail	Pass
PRO 0442 B002 (Block B)	59%	Pass	Pass
PRO 0442 B003 (Block C)	59%	Fail	Pass
PRO 0442 B004 (Block D)	59%	Fail	Pass
PRO 0442 B005 (Block E)	59%	Fail	Pass
PRO 0442 B006 (Block F)	59%	Fail	Pass

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

The residential units have capacities of 59% and are 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.

Increasing the number of nails in the plasterboard will improve the strength in some of the buildings.

Recommendations

It is recommended that;

- Strengthening schemes be developed to increase seismic capacity of the residential units to 67%NBS.
- A full level survey be conducted to confirm residual displacements.
- Veneer at height (gable ends) have their 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 Marwick Place Housing Complex, located at 53 Daniels Road, Papanui, Christchurch, 8051, following the Canterbury earthquake sequence since September 2010. The site was visited by Opus International Consultants on 8 November 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	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 26 residential units which were constructed in 1968. A site plan showing the location of the units, numbered 1 to 27 (no unit 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.

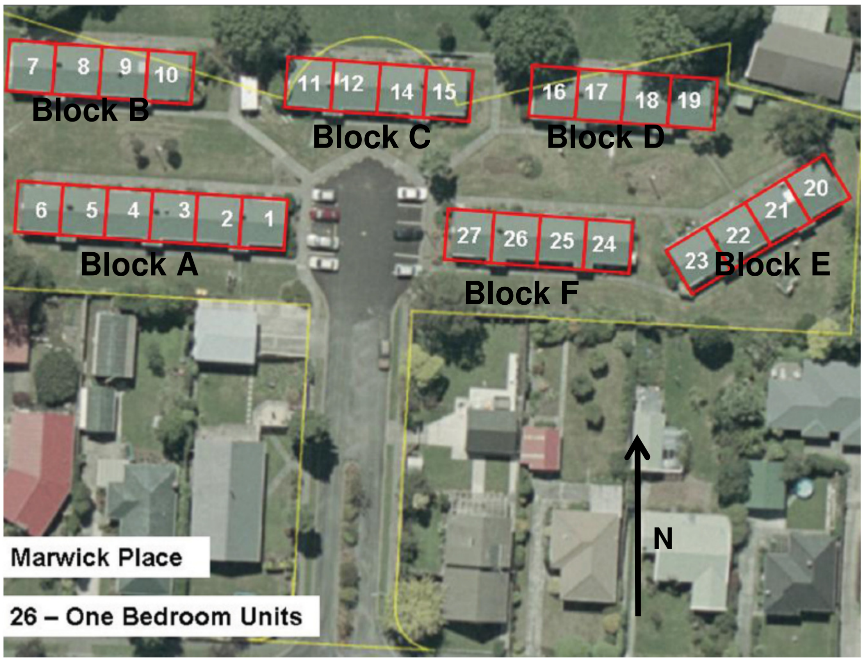


Figure 2: Site plan of Marwick Place Housing Complex.

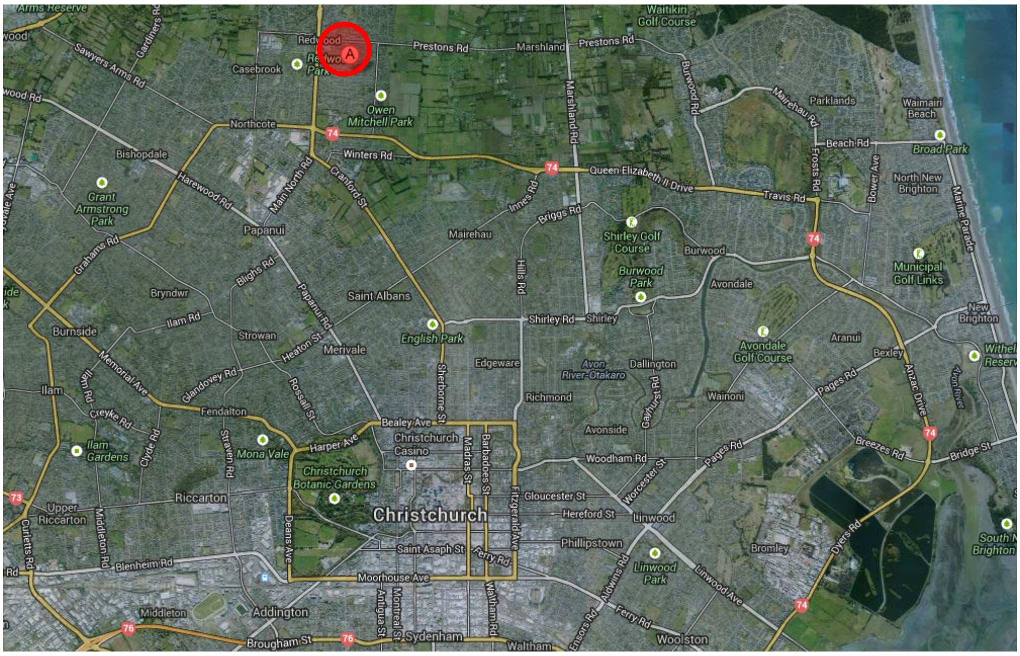


Figure 3: Location of Marwick Place (circled) relative to Christchurch City CBD (Source: Google Earth).

The residential units are timber-framed buildings with diagonal timber braces. The roof structure comprises of timber roof trusses supporting light-weight metal roofs with timber sarking. The walls and ceilings are lined with plasterboard. External walls are clad with concrete block (Blocks B, D and E), brick (Blocks A and F), and Summerhill stone (Block C). Foundations are strip footings under fire walls and around the perimeter of reinforced concrete slabs.

Chimneys exist on the majority of units (part of the fire walls). Units 9/10, 11/12, and 20/21 have had complete removal of their chimney, whereas partial chimney removal (to roof level) was observed in unit 24/25.

The units are separated by 200mm unfilled block masonry fire walls.

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.

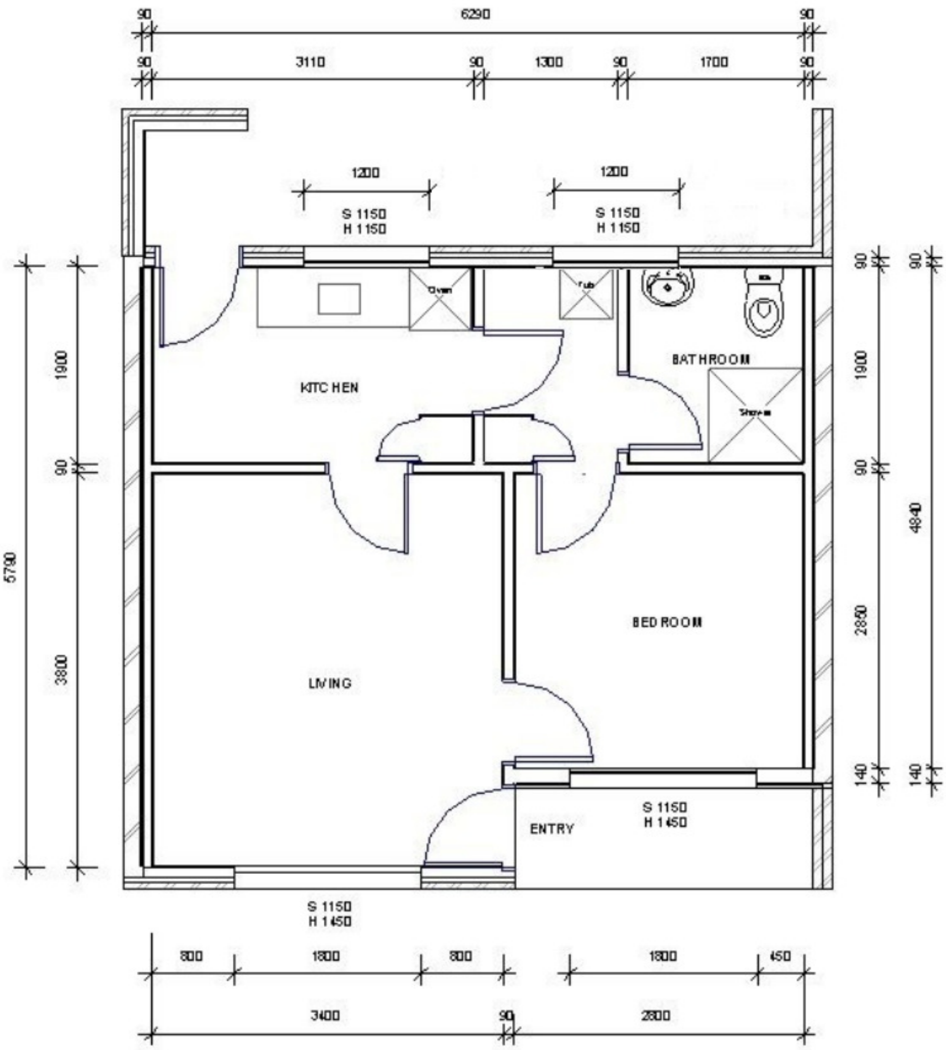


Figure 4: Typical partial floor plan of residential unit blocks.

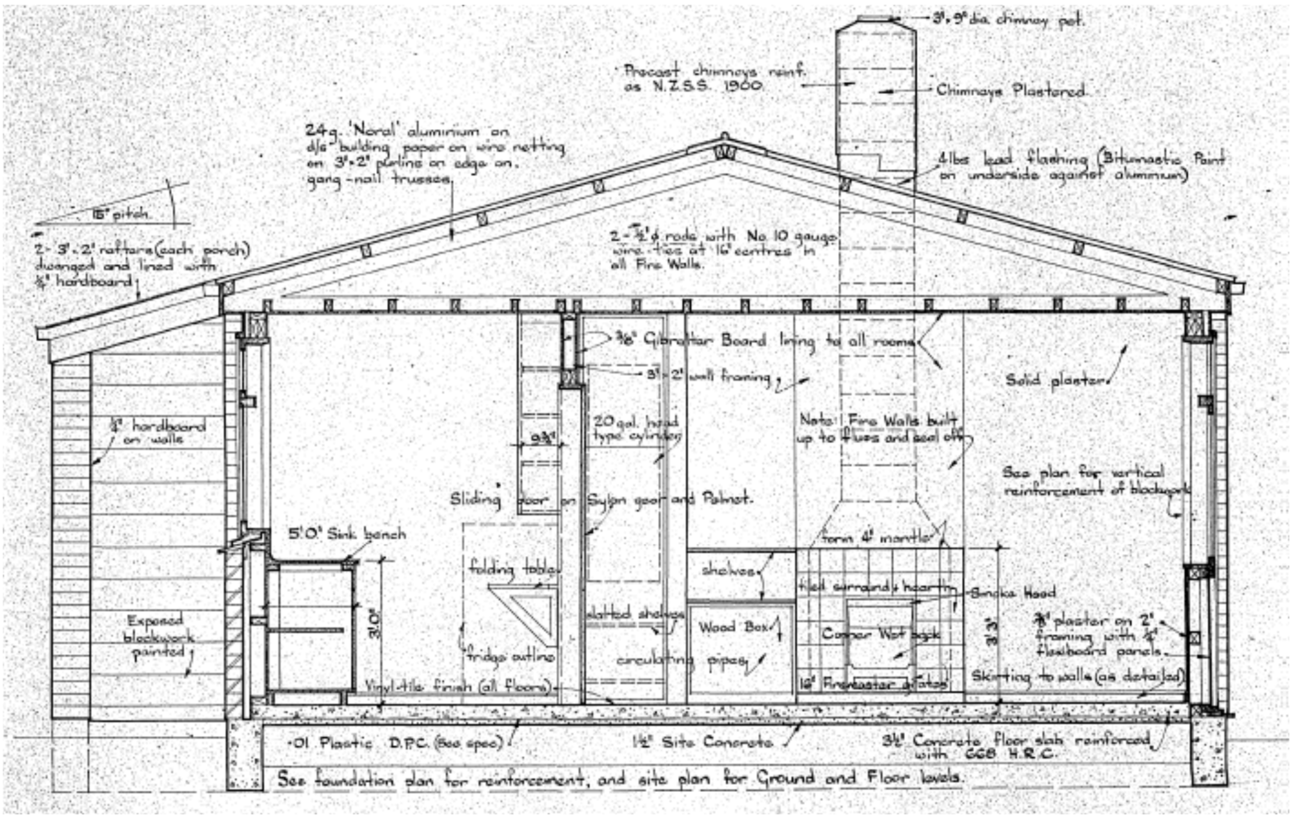


Figure 5: Cross section of Marwick Place

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 Marwick Place 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 14.7mm/m (which exceeds the 5mm/m limitation imposed by MBIE guidelines). The general slope across all units was approximately 4mm/m.

Table 2: Summary of the level survey

Block	Unit No.	Comment	Maximum Fall
A	1	Pass	-
	2	Pass	-
	3	Pass	-
	4	Fail	10.0 mm/m
	5	Pass	-
	6	Fail	5mm/m
B	7	Pass	-
	8	Pass	-
	9	Pass	-
	10	Pass	-
C	11	Pass	-
	12	Pass	-
	14	Pass	-
	15	Fail	14.7 mm/m
D	16	Fail	7.5 mm/m
	17	Fail	5.8 mm/m
	18	Pass	-
	19	Pass	-
E	20	Pass	-
	21	Fail	5 mm/m
	22	Pass	-
	23	Fail	7.6 mm/m
F	24	Fail	6.7 mm/ m
	25	Fail	5.9 mm/m
	26	Fail	5.2 mm/m
	27	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 150-450mm. Increasing the number of nails in the plasterboard will not improve the strength of the buildings.

4.3 Original Documentation

The following documentation was provided by the Christchurch City Council:

- Waimairi District Council – Single Person Pensioner Flats Marwick Place– p. 1-4/4 – Site Plan; Plans, elevations, details; Joinery details – 1967.

In addition a typical floor plan of the residential units has been produced by Opus from site measurements to help investigate potential critical structural weaknesses (CSWs) and identify details which required particular attention.

Copies of design calculations were not available for the site assessment.

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 noticeable that some residential unit blocks, and individual units, have suffered more damage than others. Overall, Units 4, 15, 16 and 23 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

Floor levels exceeded the recommended guideline of 5 mm/m in a large number of units where Units 4, 15, 16 and 23 were worst affected. Units 4 and 16 were observed to have gradual residual slopes where slopes run south and west respectively. Units 15 and 23 suffered localised displacements running towards the bathroom corner, which is a block corner in both cases. Minor residual displacements were observed in a number of units, typically running towards the south.

5.2 Foundations

Hairline cracks were observed in the foundations, typically under windowsill areas. A 2-3mm crack was observed in the foundation of Unit 18 (photo 22).

5.3 Primary Gravity Structure

No damage was observed in the gravity structure.

5.4 Primary Lateral-Resistance Structure

Minor cracking in the plasterboard was observed, typically above door frames, window frames and in the ceiling.

5.5 Non Structural Elements

Hairline cracking was observed in the veneers. The blocks with concrete block veneers suffered increased damage. A 2mm crack was observed in the veneer of Unit 15 (photo 21). Loose bricks in situ were observed at height at the end of Blocks E and F (photo 18). Cracks were observed in the concrete patio entrances (photo 20).

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 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 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.

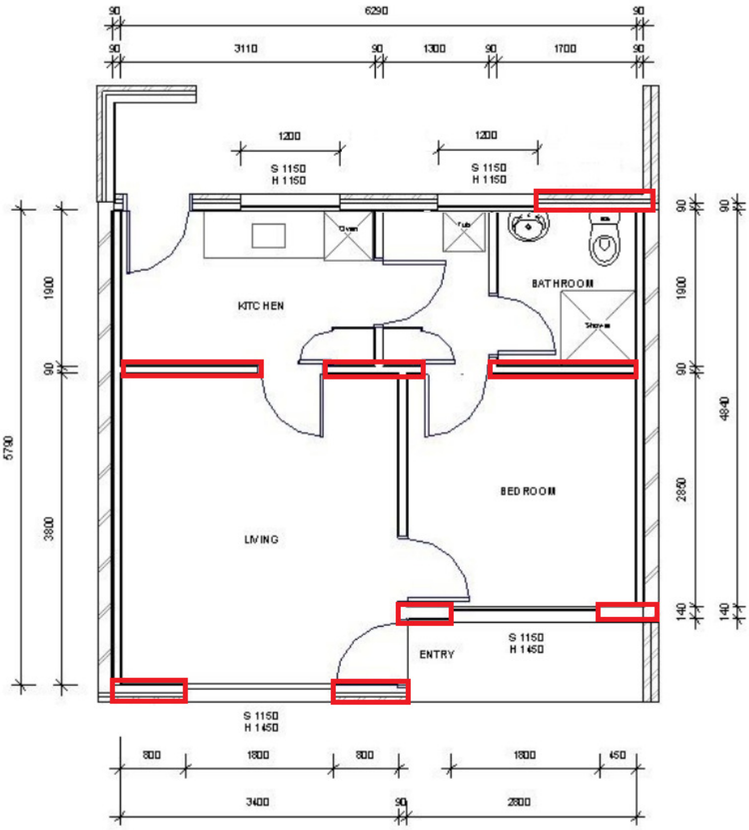


Figure 6: Walls used for bracing in the longitudinal direction.

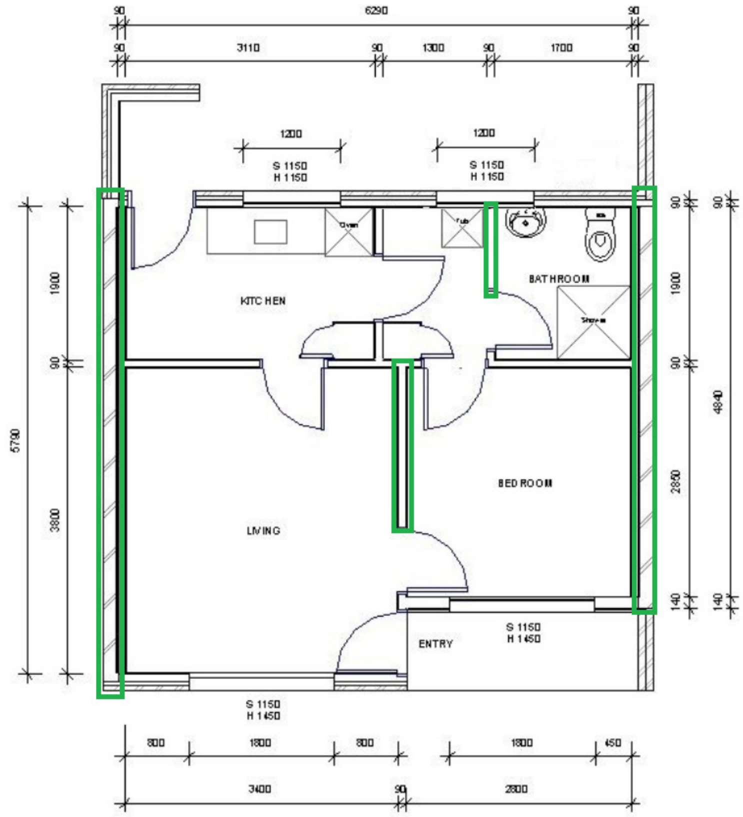


Figure 7: Walls used for bracing in the transverse direction.

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 - F	Bracing Capacity of Shear walls	59%	100%

7 Geotechnical Summary

CERA indicates that Marwick Place 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.

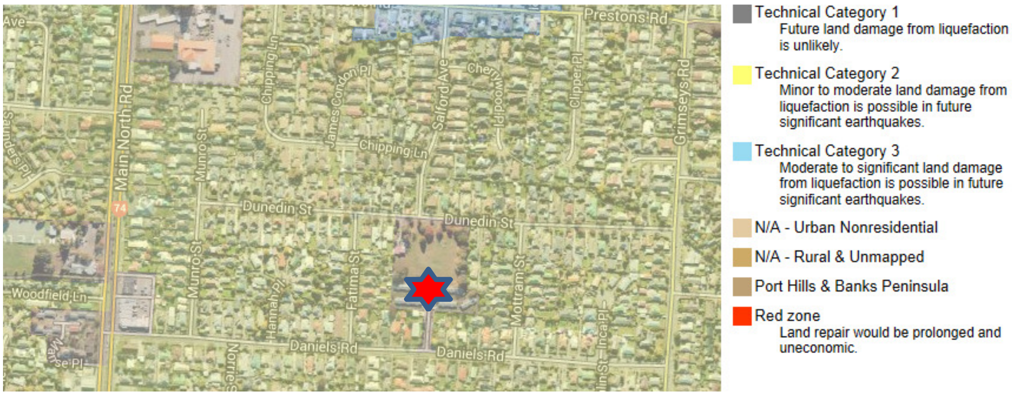


Figure 8: CERA Technical Categories map (loc. starred).

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 residential units with chimneys have a capacity of 59% 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).
- 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 seismic capacity of the residential units to 67%NBS.
- A full level survey be conducted to confirm residual displacements.
- Veneer at height (gable ends) have their 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 Marwick 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

Marwick Place Housing Complex		
No.	Item description	Photo
Residential Units Layout		
1.	Site layout (Blocks A, B and C)	
2.	Site layout (Blocks D, E, and F)	

3.	Rear elevation (Block C)	
4.	End elevation (Block C)	
5.	Front Elevation (Block E)	

6.	Front Elevation (Block A)	
7.	Typical lounge view	
8.	Typical bedroom view	

9.	Typical kitchen view	
10.	Typical bathroom view	
11.	Typical roof space showing fire wall construction	

12.	Typical roof space	
13.	Typical plasterboard cracking above windows and at roof line	

14.	450mm nail spacing (Unit 6)	
15.	Typical crack in ceiling diaphragm	

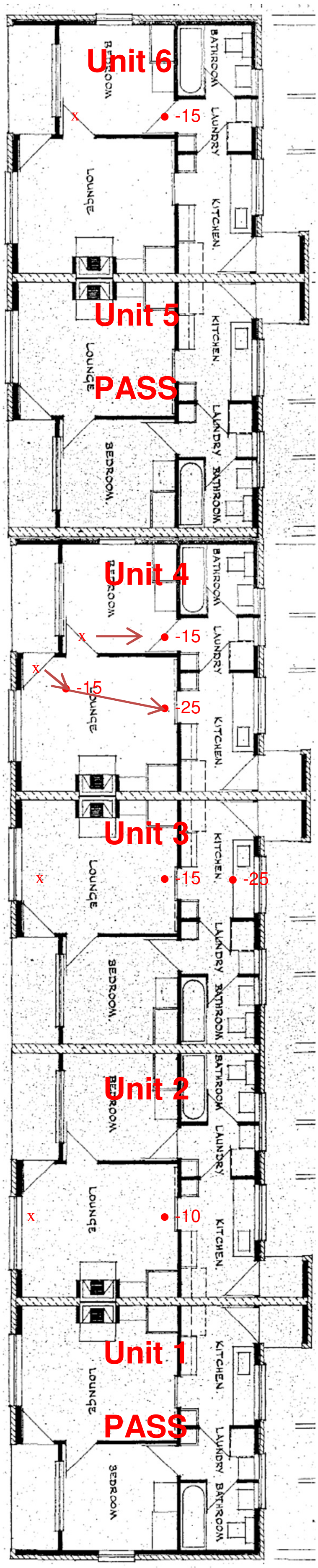
16.	150-350 mm nail spacing (Unit 12)	
17.	Separation of skirting board and floor	

18.	Loose block in situ	
19.	Concrete spalling of foundations	
20.	Cracking of concrete patio	

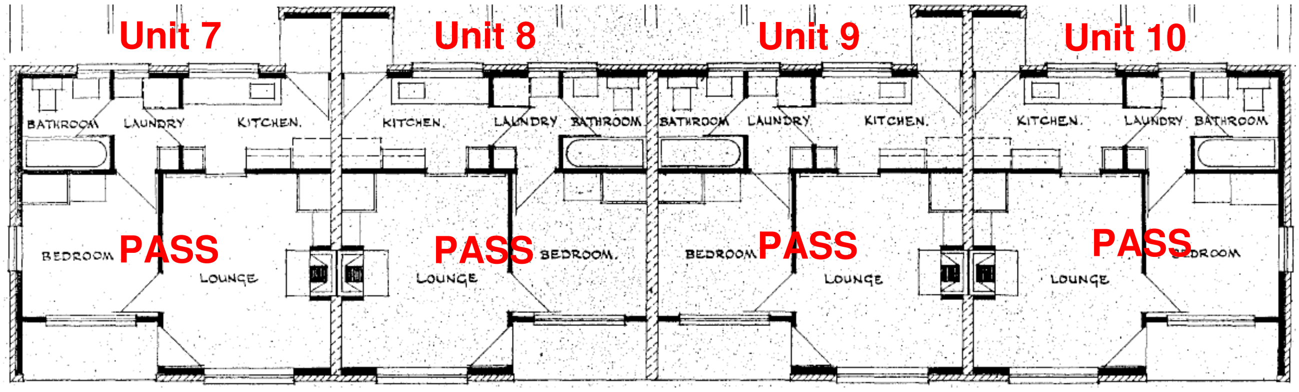
21.	2mm stepped crack in Unit 15 veneer	
22.	2mm foundation crack in Unit 18	

Appendix B – Level Survey

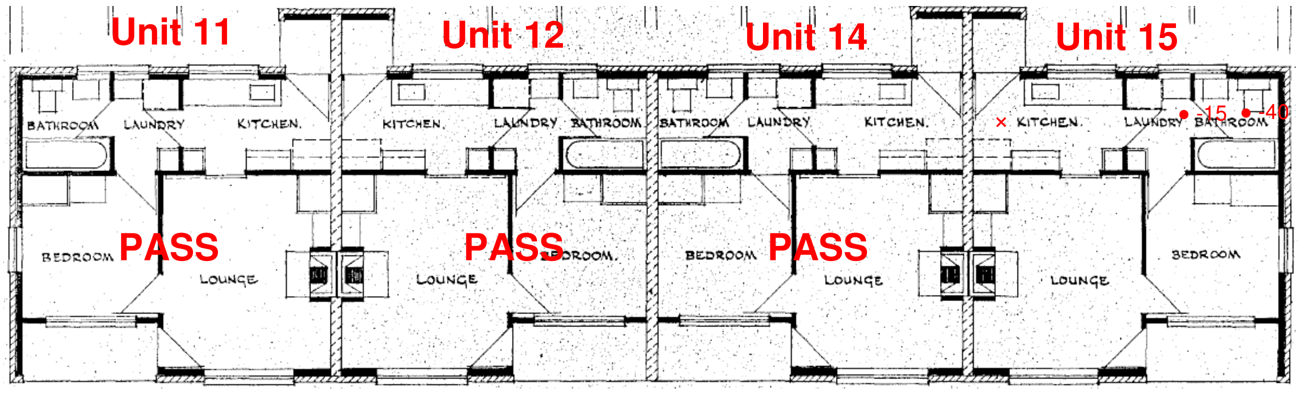
Block A


Unit 6
-15
x
Unit 5
PASS
Unit 4
x
-15
x
-15
-25
Unit 3
x
-15
-25
Unit 2
x
-10
Unit 1
PASS
BATHROOM
LAUNDRY
KITCHEN.
LOUNGE
BEDROOM.

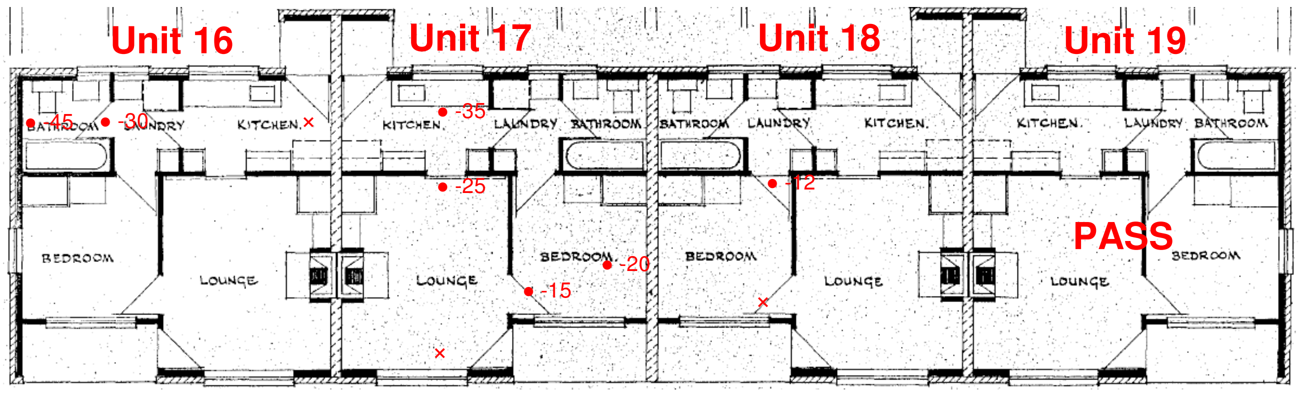
Block B



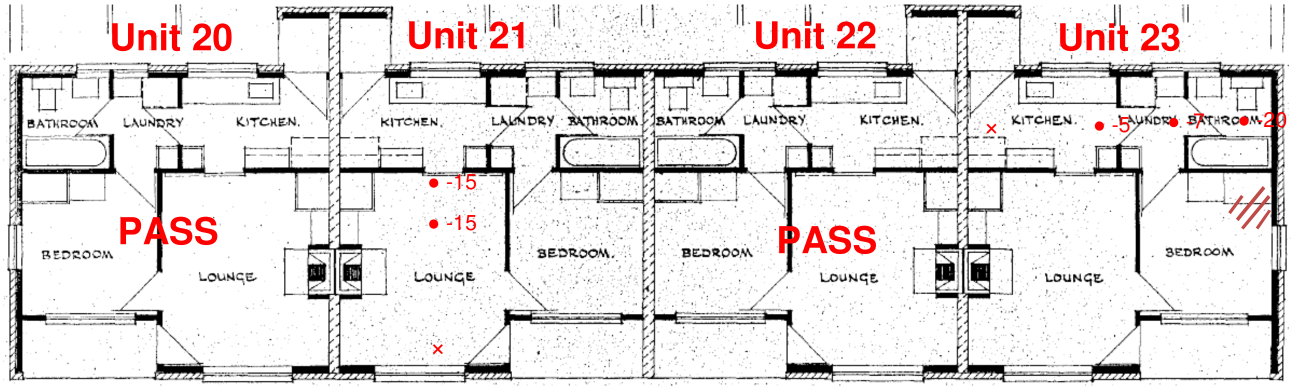
Block C



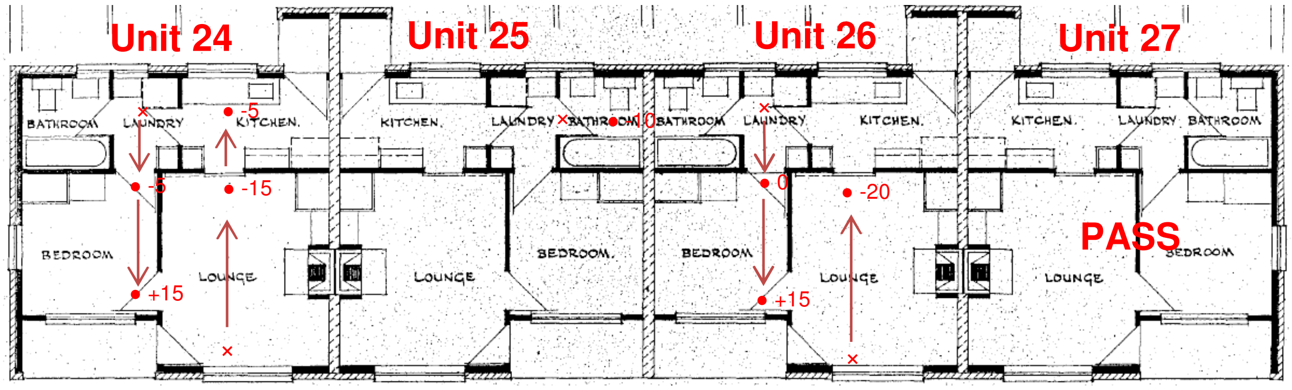
Block D



Block E



Block F



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:	Marwick Place Housing Complex	Reviewer:	Mary Ann Halliday
	Unit / No: 53 / Street: Daniels	CPEng No:	67073
Building Address:	53 Daniels	Company:	Opus International Consultants
Legal Description:		Company project number:	6-QC378.00
		Company phone number:	
	Degrees / Min / Sec		
GPS south:	43 / 28 / 40.30	Date of submission:	17-Jan-14
GPS east:	172 / 37 / 21.53	Inspection Date:	8/11/2013
		Revision:	1
Building Unique Identifier (CCC):	PRO0442	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 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):	3.00	height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	212		
Age of Building (years):	45	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	timber sarking
Floors:	concrete flat slab	slab thickness (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 heavy	describe	Brick, summerhill stone and concrete block
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?:	yes	Describe:	
CSWs:	Damage?:	no	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:	59% ##### %NBS from IEP below	If IEP not used, please detail assessment methodology:	Equivalent Static
	Assessed %NBS after e'quakes:	59%		
Across	Assessed %NBS before e'quakes:	100% ##### %NBS from IEP below		
	Assessed %NBS after e'quakes:	100%		

Detailed Engineering Evaluation Summary Data V1.14

Location

Building Name:	Marwick Place Housing Complex		Reviewer:	Mary Ann Halliday
	Unit No: Street		CPEng No:	67073
Building Address:	53 Daniels		Company:	Opus International Consultants
Legal Description:			Company project number:	6-QC378.00
			Company phone number:	
	Degrees Min Sec			
GPS south:	43 28 40.30		Date of submission:	17-Jan-14
GPS east:	172 37 21.53		Inspection Date:	8/11/2013
			Revision:	1
Building Unique Identifier (CCC):	PRO0442		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 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):	3.00		height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	142			
Age of Building (years):	45		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		
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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

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:	0.10	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
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Non-structural elements

Stairs:			
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(refer DEE Table 4-2)

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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?:	yes	Describe:	
CSWs:	Damage?:	no	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:	59% ##### %NBS from IEP below	If IEP not used, please detail assessment methodology:	Equivalent Static
	Assessed %NBS after e'quakes:	59%		
Across	Assessed %NBS before e'quakes:	100% ##### %NBS from IEP below		
	Assessed %NBS after e'quakes:	100%		

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