

*Christchurch City Council*

**Ka Wahine Trust  
Halfway House  
PRO 2538**

**Detailed Engineering Evaluation  
Quantitative Assessment Report**



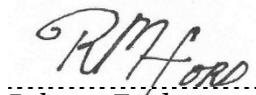
*Christchurch City Council*

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# **Ka Wahine Trust Halfway House Quantitative Assessment Report**

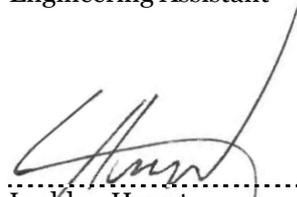
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Approved for  
Release By

  
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Mary Ann Halliday  
Senior Structural Engineer

# Summary

Ka Wahine Trust Halfway House  
PRO 2538

Detailed Engineering Evaluation  
Quantitative Report - Summary  
Final

## Background

This is a summary of the quantitative report for the Ka Wahine Trust Halfway House, 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 three structures on the site, these being the house, the additional accommodation building and the garage.

## Key Damage Observed

The house has suffered distributed amounts of minor damage including cracking of internal wall linings and ceiling diaphragms. Minor cracking was observed to the concrete perimeter wall. Some stepped cracking was also noted on the brick veneer. This damage is considered to not affect the seismic capacity of the structure.

No damage was observed in the sleep-out.

The garage suffered severe damage to structural elements including significant cracking of the concrete block wall. This damage is expected as the concrete block walls are believed to be unreinforced.

## Level Survey

Floor slopes in each room were assessed with a laser level survey. All were less than the 5mm/m limitation set out in the MBIE guidelines [6], as shown below.

## Internal Lining Nail Spacings

No internal lining nails were recorded in the main house, as the walls are lined with lathe and plaster. Internal lining nail spacings in the sleep-out were found to be between 200-250mm.

## Critical Structural Weaknesses

The unreinforced masonry in the garage is considered a critical structural weakness.

No critical structural weaknesses were found in the other buildings on site.

## Indicative Building Strength

**Table A: Summary of Seismic Performance by Blocks**

Block	NBS%	Indicative Floor Levels	Nail Spacings
PRO 2538 B001 (House)	100%	Pass	-
PRO 2538 B002 (Sleep-out)	100%	Pass	Pass
PRO 2538 B003 (Garage)	<33%	-	-

The main residential building has a capacity of 100% NBS.

The sleep-out building has a capacity of 100% NBS.

The garage has a capacity of <33% NBS as limited by the out of plane shear capacity of the concrete block walls.

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

### **Recommendations**

It is recommended that;

- Cosmetic repairs be undertaken as required.
- The concrete block garage be strengthened or replaced.

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# 1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council to undertake a detailed seismic assessment of the Ka Wahine Trust Halfway House, located at 18 McGregors Road, Bromley, following the Canterbury earthquake sequence since September 2010. The site was visited by Opus International Consultants on 12 November 2013.

The purpose of the assessment is to determine if the buildings on the property 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<sup>1</sup> 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.

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<sup>1</sup> 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 three buildings: a three-bedroom house, a three-bedroom sleep-out (labelled 'Accom.' in Council Building Register) and a garage. The original construction date of the house and the garage is unknown. The garage was extended in 1966. The sleep-out was erected in 1989. A site plan showing the buildings is shown in Figure 2. Figure 3 shows the location of the site in Christchurch City.



Figure 2: Site plan of Ka Wahine Trust Halfway House.



Figure 3: Location of Ka Wahine Trust Halfway House (circled) relative to Christchurch City CBD (Source: Google Earth).

The main house is a timber-framed building with diagonal timber braces. The roof structure comprises of timber roof framing supporting a heavy, concrete tile roof. The walls are clad with lathe and plaster. The ceilings are sprayed with a plaster coating, except where plasterboard lining has been used for repair works. External walls are clad with brick veneer. Foundations consist of a concrete perimeter wall with concrete piles.

The sleep-out is a timber-framed Skyline building. The roof structure comprises of timber roof framing supporting a light-weight metal roof. The walls and ceilings are lined with plasterboard. External walls are clad with Coloursteel metal. Foundations consist of timber piles.

The garage is a potentially unreinforced concrete block building. The roof structure comprises of timber roof trusses supporting a light-weight metal roof. The walls and ceiling are unlined. The foundation is a concrete slab.

Figure 4, Figure 5 and Figure 6 show floor plans of the house, sleep-out and garage respectively. These were produced from site measurements by Opus. Figure 7 shows a cross-section of the sleep-out, from the original Building Permit application. Figure 8 shows a cross-section of the garage from when the building was extended. No relevant cross-section could be found for the main residential building. These drawings were used in calculations.

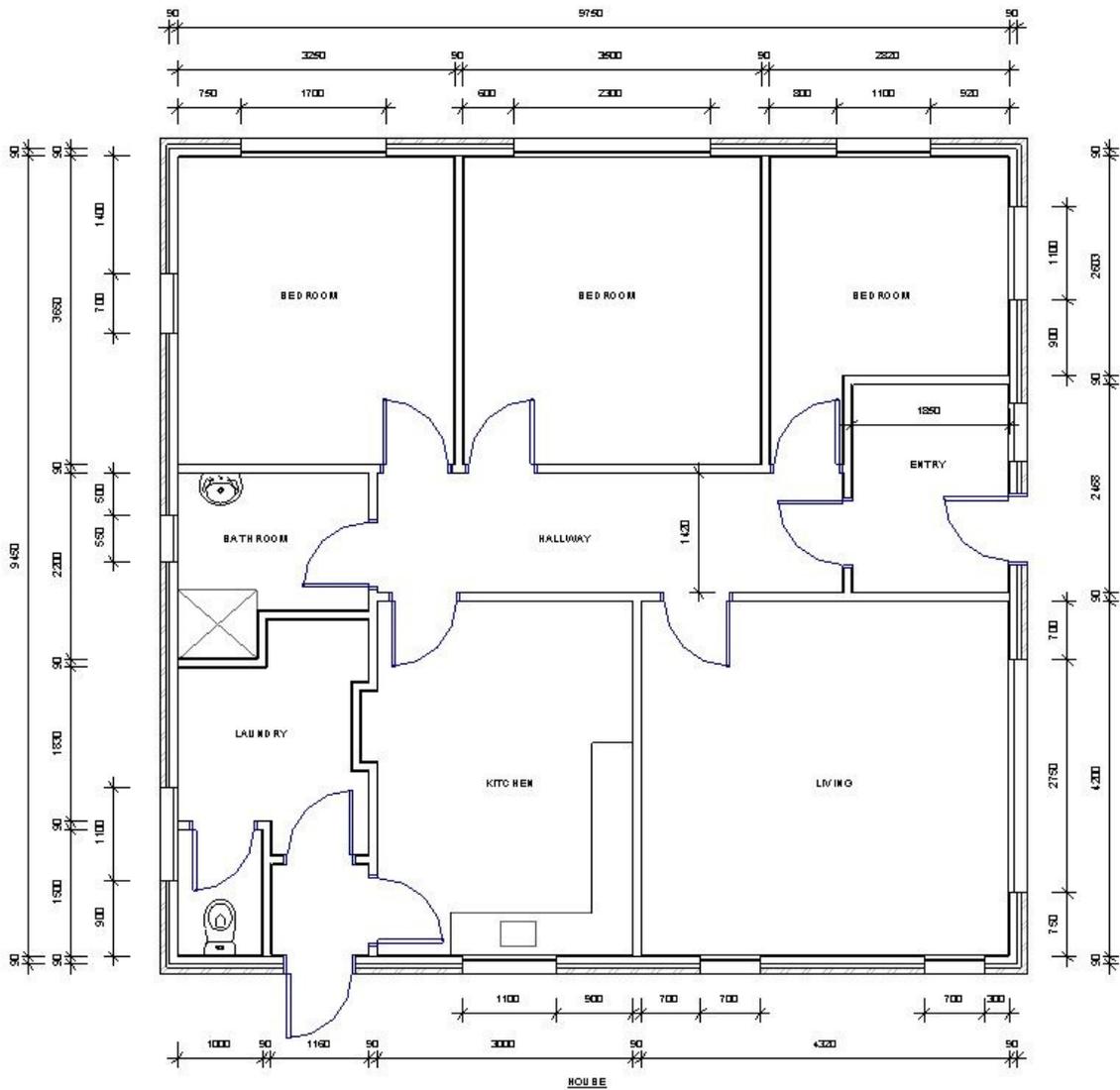


Figure 4: Floor plan of house.

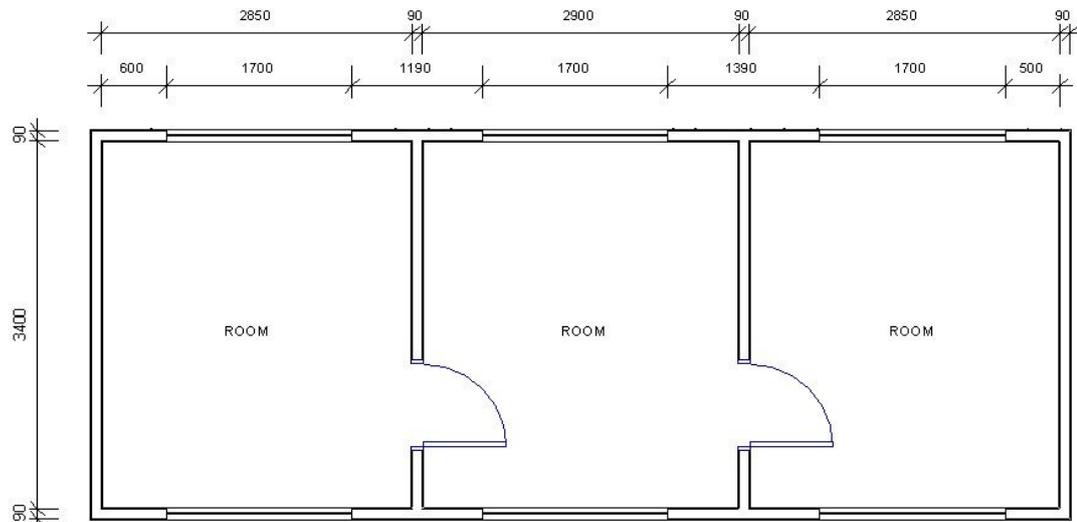


Figure 5: Plan view of sleep-out.

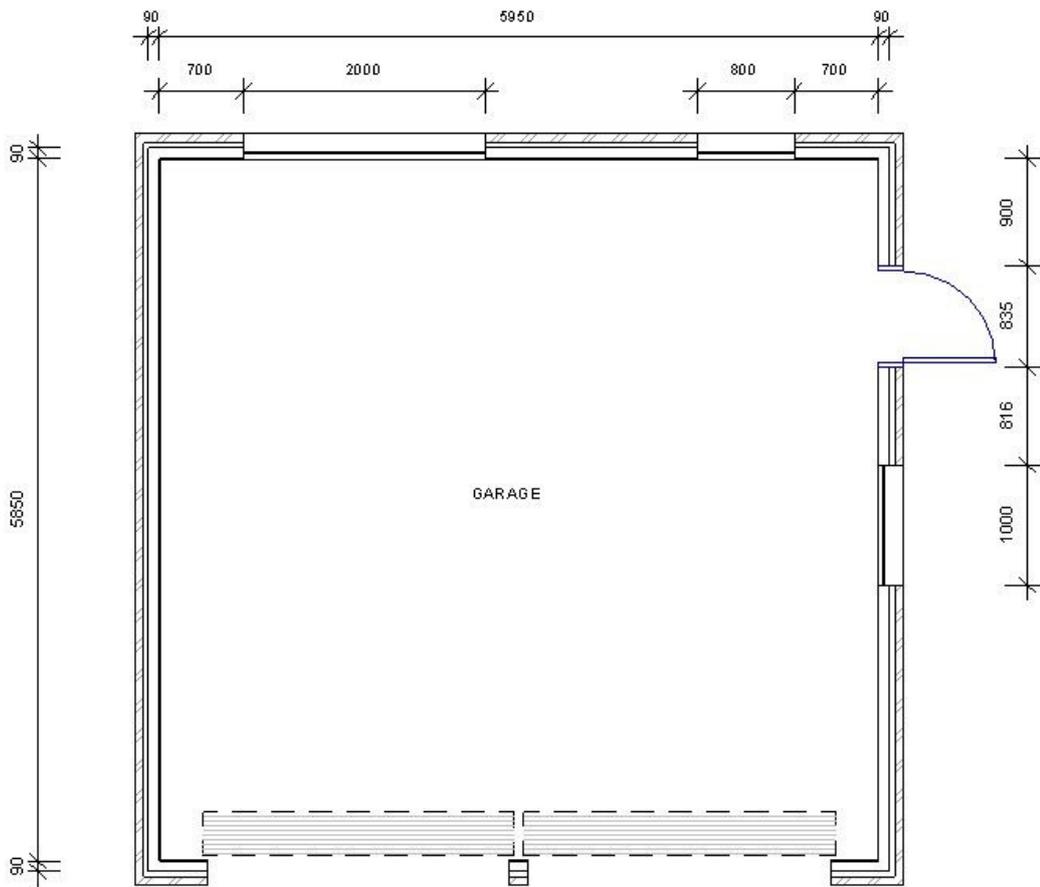


Figure 6: Plan view of garage.

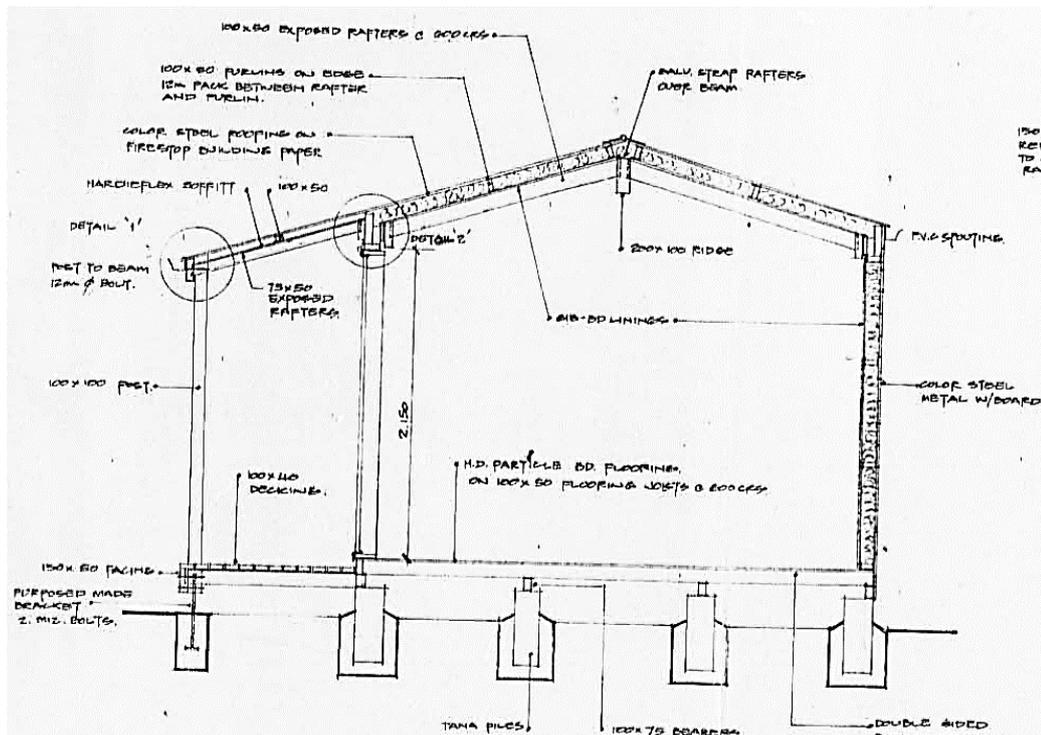


Figure 7: Cross-section of sleep-out.

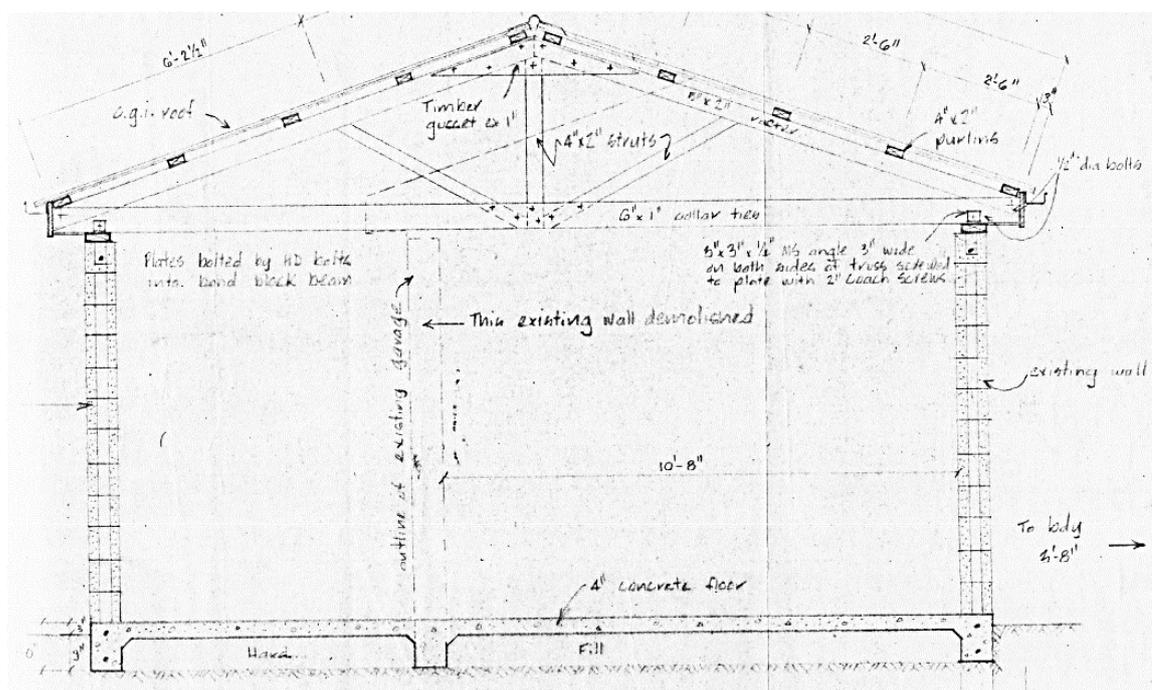


Figure 8: Cross-section of garage.

## 4.2 Survey

### 4.2.1 Level Survey

A full level survey was not deemed to be necessary at Ka Wahine Trust Halfway House 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 room so that differentials in vertical levels could be measured at the maximum distance across and through rooms. These values could then be used to determine the floor slope of various part of the house. This survey was limited by short lines of sight offered by the layout of the house. For this site, all floor slopes were less than the 5mm/m limitation imposed by MBIE guidelines.

Table 2: Summary of the Level Survey

Block	Comment	Maximum Fall*
House	Pass	-
Sleep-out	Pass	-
Garage	Not assessed	-

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

### 4.2.2 Nail Spacings

No internal lining nails were recorded in the main house as the walls are lined with lathe and plaster.

Internal lining nail spacings in the sleepout were measured to be between 200-250mm.

## 4.3 Original Documentation

The following original documentation was provided to Opus by the Christchurch City Council:

- Christchurch City Council – 18 McGregors Rd, Sleep-out and Study – Building Permit Application – Permit No. 88 3332 – Application documents; Plan, elevations and cross-section – 1988
- Christchurch City Council – 18 McGregors Rd, Garage Extension – Building Permit Approval – Plan and cross-section – 1966

No original documentation on the house was provided. No original design calculations for any of the buildings were 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.

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

### 5.1 Residual Displacements

No significant ground movement was observed anywhere on the property.

### 5.2 Foundations

Some cracking was observed in the perimeter footing of the house (photo 4).

### 5.3 Primary Gravity Structure

Severe cracking in the block-work of the garage was observed (photo 16).

### 5.4 Primary Lateral-Resistance Structure

Hairline cracking of the ceiling diaphragms and wall linings was commonly observed. This was predominantly observed to run from the corners of windows, doors and through ceiling lights (photos 7 and 8). In some cases it was observed that the wall lining had bulged without actually cracking (photo 9). More severe cracking was noted in the wall above the fire place in the lounge (photo 10). Emergency remediation of the ceilings in the lounge and one bedroom had been conducted by fixing Gib board to the ceiling (photos 11 and 12).

## 5.5 Non Structural Elements

Step cracking and mortar cracking was observed in the brick veneer of the house (photos 5 and 6).

## 5.6 General Observations

The house and sleep out 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.

The garage appeared to have performed poorly, as would be expected for unreinforced concrete masonry buildings. Severe structural damage has occurred 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.

## 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.

The unreinforced masonry in the garage is considered a critical structural weakness.

No critical structural weaknesses were found in the other buildings on site.

## 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 9 through to Figure 14, were used for bracing in their respective directions.

The garage was not assessed as the method of construction and damage to the walls determined the structure was earthquake prone by inspection based on engineering judgement and other structures of a similar nature.

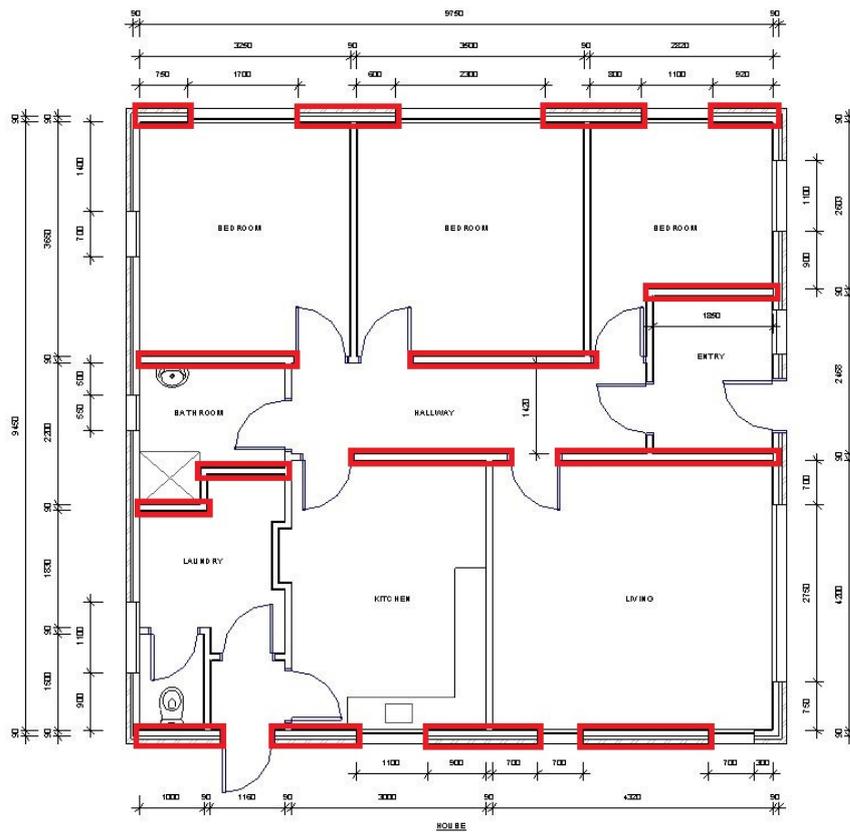


Figure 9: Walls used for bracing in the longitudinal direction, main building.

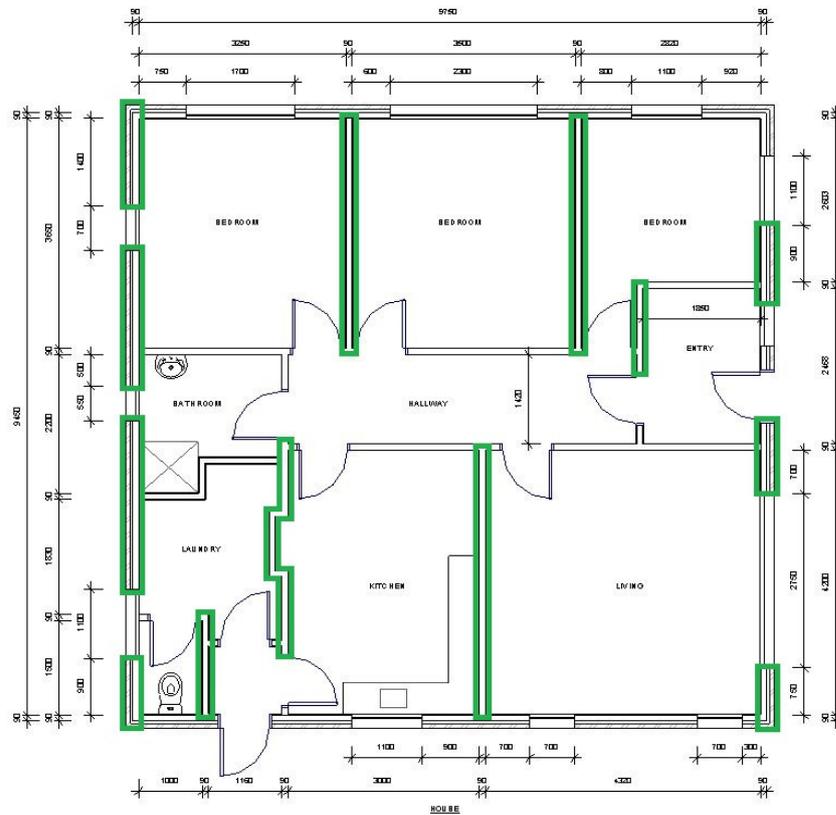


Figure 10: Walls used for bracing in the transverse direction, main building.

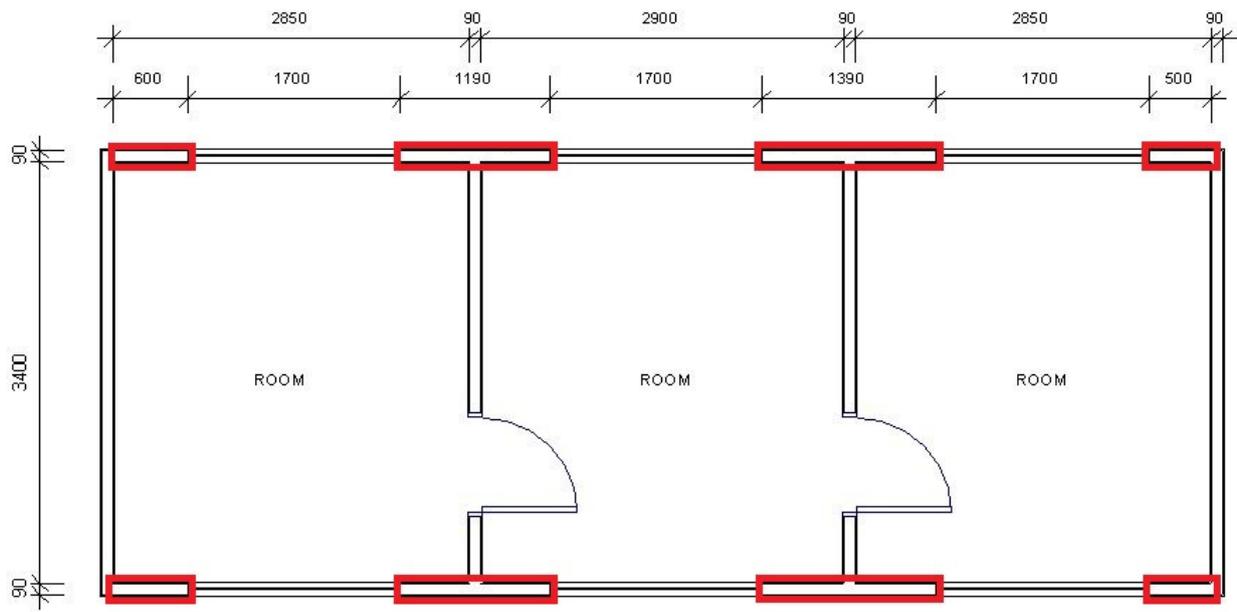


Figure 11: Walls used for bracing in the longitudinal direction, sleepout.

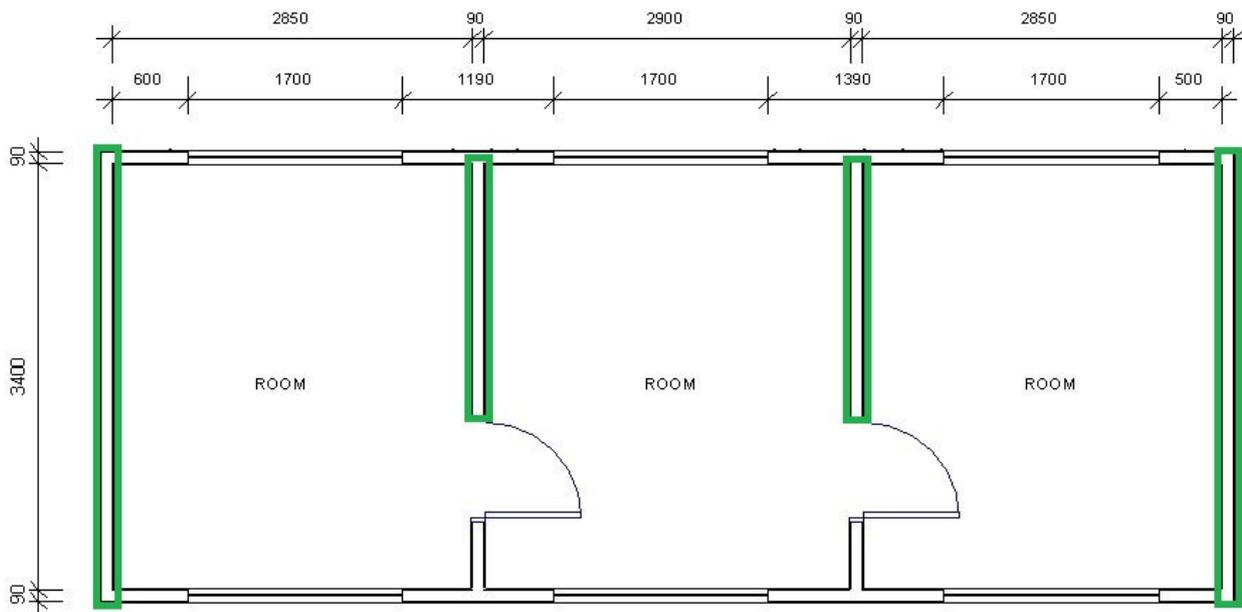


Figure 12: Walls used for bracing in the transverse direction, sleepout.

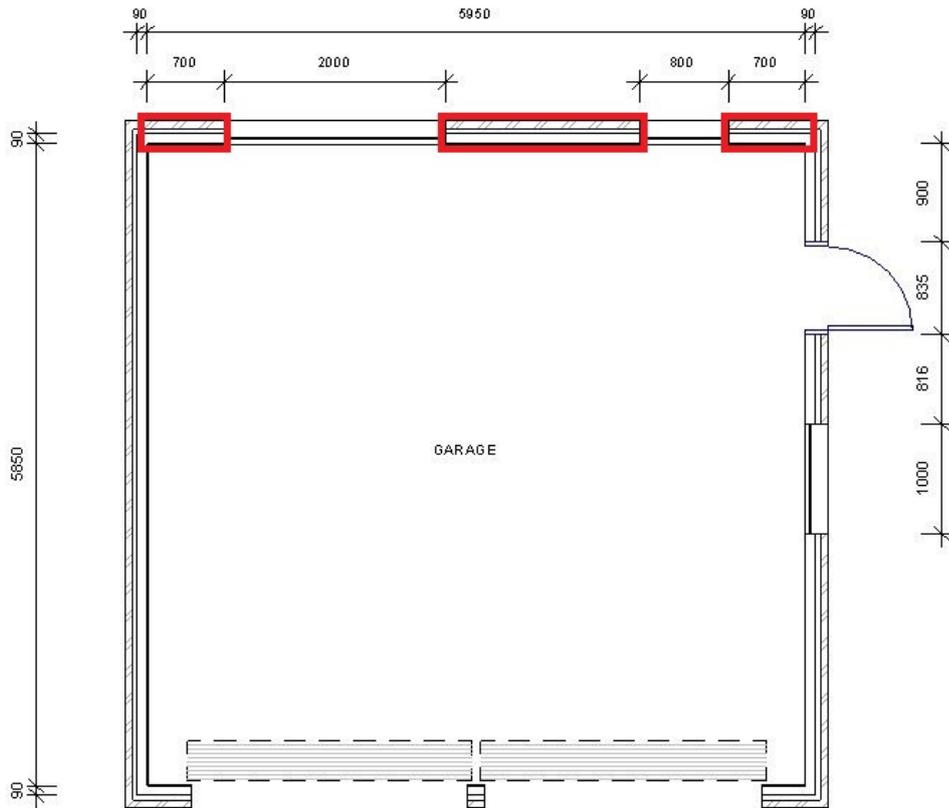


Figure 13: Walls used for bracing in the longitudinal direction, garage.

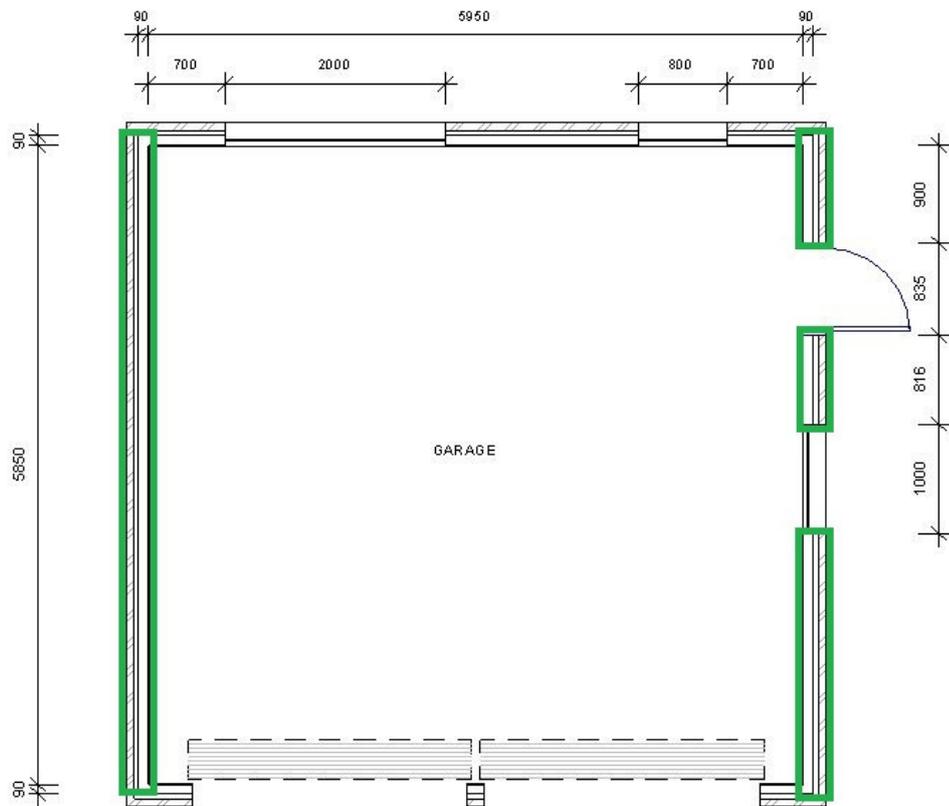


Figure 14: Walls used for bracing in the transverse direction, garage.

### 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**

<b>Building Description</b>	<b>Critical element</b>	<b>% NBS based on calculated capacity in longitudinal direction</b>	<b>% NBS based on calculated capacity in transverse direction.</b>
House	Timber bracing walls in-plane	100%	100%
Sleep-out	Timber bracing walls in-plane	100%	100%
Garage	Unreinforced block masonry in both directions	<33%	<33%

## 7 Geotechnical Summary

CERA indicates that Ka Wahine Trust Halfway House is located in a TC2 zone (as shown in Figure 15). This classification suggests future significant earthquakes will cause minor to moderate land damage due to liquefaction and settlement.



Figure 15: CERA Technical Categories map (loc. starred).

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

## 8 Conclusions

- The main residential building 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.
- The sleepout building 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.
- The garage has a capacity of <33% NBS, as limited by the in-plane capacity of the bracing walls. They are deemed to be a 'high risk' in a design seismic event according to NZSEE guidelines. Their level of risk is 10-25+ times that of a 100% NBS building (Figure 1).

## 9 Recommendations

It is recommended that;

- Cosmetic repairs be undertaken as required.
- The concrete block garage be strengthened or replaced.

## 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 Ka Wahine Trust Halfway House. 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**

**Ka Wahine Trust Halfway House– Detailed Engineering Evaluation**

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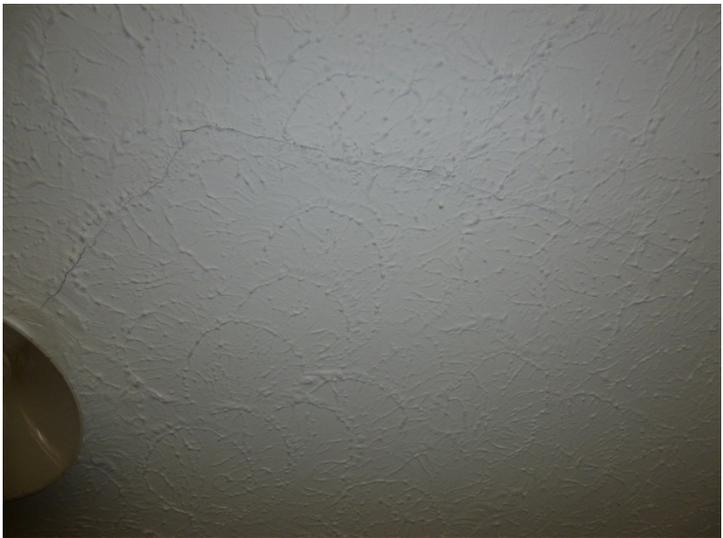
Ka Wahine Trust Halfway House		
No.	Item description	Photo
Residential Units Layout		
1.	House exterior view (front)	
2.	House exterior view (north-east side)	

**Ka Wahine Trust Halfway House– Detailed Engineering Evaluation**

<p>3.</p>	<p>House exterior view (back)</p>	 A photograph showing the rear exterior of a single-story brick house. The house has a dark tiled roof with a white chimney pipe. The brickwork is reddish-brown. In the foreground, there is a concrete driveway with a red plastic chair and two black trash bins with green and yellow lids. The sky is overcast.
<p>4.</p>	<p>House: Typical cracking in perimeter footing of house</p>	 A close-up photograph of a concrete foundation wall. A prominent vertical crack runs down the center of the wall. The concrete is grey and shows signs of weathering and moss growth.
<p>5.</p>	<p>House: Cracking in brick veneer at back of house</p>	 A close-up photograph of a brick wall. The bricks are reddish-brown with white mortar joints. There are several visible cracks in the mortar joints and the bricks themselves, indicating structural damage.

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6.	House: Cracking of brick veneer at front of house	
7.	House: Typical cracking in ceiling diaphragm	
8.	House: Typical cracking in wall	

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9.	House: Typical bulging in wall lining	 A photograph showing a close-up of a light-colored wall. The wall surface exhibits a distinct bulging or unevenness, particularly towards the right side of the frame. A portion of a dark wooden object, possibly a door or window frame, is visible in the upper right corner.
10.	House: Cracking in wall above fire place	 A photograph of a light-colored wall. A prominent, irregular crack runs vertically down the center of the wall. In the lower right corner, there is a small blue vase containing a bouquet of white roses. A dark object, likely a fire place mantel or part of a fireplace, is visible at the bottom edge of the frame.

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<p>11.</p>	<p>House: Ceiling remediation in lounge</p>	
<p>12.</p>	<p>House: Ceiling remediation in bedroom</p>	
<p>13.</p>	<p>Sleep-out exterior elevation (front)</p>	

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<p>14.</p>	<p>Garage exterior elevation (south-west end)</p>	
<p>15.</p>	<p>Garage exterior elevation (back)</p>	
<p>16.</p>	<p>Cracking in garage</p>	

## **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  $\mu$  of 2 was assumed for the residential units and 1 was used for the garages.

## Analysis Procedure

As the house and the sleepout 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.

The garage was not assessed as the method of construction and damage to the walls determined the structure was earthquake prone by inspection based on engineering judgement and other structures of a similar nature.

## 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**

<b>Location</b>		Building Name: <u>Ka Wahine Trust Halfway House (sleepout)</u>	Reviewer: <u>Mary Ann Halliday</u>
Building Address: <u>18</u>	Unit No: <u>McGregors</u>	CPEng No: <u>67073</u>	
Legal Description: <u></u>		Company: <u>Opus International Consultants</u>	
		Company project number: <u>6-OC366.00</u>	
		Company phone number: <u></u>	
	Degrees Min Sec	Date of submission: <u>27-Feb-14</u>	
GPS south: <u>43</u>	<u>32</u> <u>13.40</u>	Inspection Date: <u>12/11/2013</u>	
GPS east: <u>172</u>	<u>40</u> <u>54.84</u>	Revision: <u>1</u>	
Building Unique Identifier (CCC): <u>PRO2538</u>		Is there a full report with this summary? <u>yes</u>	

<b>Site</b>	Site slope: <u>flat</u>	Max retaining height (m): <u></u>
	Soil type: <u></u>	Soil Profile (if available): <u></u>
	Site Class (to NZS1170.5): <u>D</u>	
	Proximity to waterway (m, if <100m): <u></u>	If Ground improvement on site, describe: <u></u>
	Proximity to cliff top (m, if < 100m): <u></u>	
	Proximity to cliff base (m,if <100m): <u></u>	Approx site elevation (m): <u></u>

<b>Building</b>	No. of storeys above ground: <u>1</u>	single storey = 1	Ground floor elevation (Absolute) (m): <u></u>
	Ground floor split? <u>no</u>		Ground floor elevation above ground (m): <u></u>
	Storeys below ground: <u>0</u>		
	Foundation type: <u>bored cast-insitu concrete piles</u>		if Foundation type is other, describe: <u></u>
	Building height (m): <u>3.00</u>	height from ground to level of uppermost seismic mass (for IEP only) (m): <u></u>	
	Floor footprint area (approx): <u>31</u>		Date of design: <u>1976-1992</u>
	Age of Building (years): <u>24</u>		
	Strengthening present? <u>no</u>		If so, when (year)? <u></u>
	Use (ground floor): <u>multi-unit residential</u>		And what load level (%g)? <u></u>
	Use (upper floors): <u></u>		Brief strengthening description: <u></u>
	Use notes (if required): <u></u>		
	Importance level (to NZS1170.5): <u>IL2</u>		

<b>Gravity Structure</b>	Gravity System: <u>frame system</u>	
	Roof: <u>timber framed</u>	rafter type, purlin type and cladding: <u></u>
	Floors: <u>timber</u>	joist depth and spacing (mm): <u></u>
	Beams: <u>none</u>	overall depth x width (mm x mm): <u></u>
	Columns: <u>timber</u>	typical dimensions (mm x mm): <u></u>
	Walls: <u>non-load bearing</u>	<u>0</u>

<b>Lateral load resisting structure</b>	Lateral system along: <u>other (note)</u>	<b>Note: Define along and across in detailed report!</b>	describe system: <u>Timber Framed with Steel Cladding</u>
	Ductility assumed, μ: <u>2.00</u>	0.00	estimate or calculation? <u>estimated</u>
	Period along: <u>0.10</u>		estimate or calculation? <u></u>
	Total deflection (ULS) (mm): <u></u>		estimate or calculation? <u></u>
	maximum interstorey deflection (ULS) (mm): <u></u>		
	Lateral system across: <u>other (note)</u>	0.00	describe system: <u>Timber Framed with Steel Cladding</u>
	Ductility assumed, μ: <u>2.00</u>		estimate or calculation? <u>estimated</u>
	Period across: <u>0.10</u>		estimate or calculation? <u></u>
	Total deflection (ULS) (mm): <u></u>		estimate or calculation? <u></u>
	maximum interstorey deflection (ULS) (mm): <u></u>		

<b>Separations:</b>	north (mm): <u></u>	leave blank if not relevant
	east (mm): <u></u>	
	south (mm): <u></u>	
	west (mm): <u></u>	

<b>Non-structural elements</b>	Stairs: <u></u>	describe: <u></u>
	Wall cladding: <u>profiled metal</u>	describe: <u>red brick</u>
	Roof Cladding: <u>Metal</u>	describe: <u>concrete tiles</u>
	Glazing: <u>aluminium frames</u>	
	Ceilings: <u>none</u>	
	Services(list): <u></u>	

<b>Available documentation</b>	Architectural: <u>partial</u>	original designer name/date: <u></u>
	Structural: <u>partial</u>	original designer name/date: <u></u>
	Mechanical: <u>none</u>	original designer name/date: <u></u>
	Electrical: <u>none</u>	original designer name/date: <u></u>
	Geotech report: <u>none</u>	original designer name/date: <u></u>

<b>Damage</b>	Site performance: <u>Good</u>	Describe damage: <u></u>
Site: (refer DEE Table 4-2)	Settlement: <u>none observed</u>	notes (if applicable): <u></u>
	Differential settlement: <u>none observed</u>	notes (if applicable): <u></u>
	Liquefaction: <u>none apparent</u>	notes (if applicable): <u></u>
	Lateral Spread: <u>none apparent</u>	notes (if applicable): <u></u>
	Differential lateral spread: <u>none apparent</u>	notes (if applicable): <u></u>
	Ground cracks: <u>none apparent</u>	notes (if applicable): <u></u>
	Damage to area: <u>none apparent</u>	notes (if applicable): <u></u>

<b>Building:</b>	Current Placard Status: <u>green</u>	
Along	Damage ratio: <u>0%</u>	Describe how damage ratio arrived at: <u></u>
	Describe (summary): <u></u>	
Across	Damage ratio: <u>0%</u>	$Damage\_Ratio = \frac{(\%NBS\ (before) - \%NBS\ (after))}{\%NBS\ (before)}$
	Describe (summary): <u></u>	
Diaphragms	Damage?: <u>no</u>	Describe: <u></u>
CSWs:	Damage?: <u>no</u>	Describe: <u></u>
Pounding:	Damage?: <u>no</u>	Describe: <u></u>
Non-structural:	Damage?: <u>yes</u>	Describe: <u></u>

<b>Recommendations</b>	Level of repair/strengthening required: <u>minor non-structural</u>	Describe: <u></u>
	Building Consent required: <u>no</u>	Describe: <u></u>
	Interim occupancy recommendations: <u>full occupancy</u>	Describe: <u></u>
Along	Assessed %NBS before e'quakes: <u>100%</u>	#### %NBS from IEP below
	Assessed %NBS after e'quakes: <u>100%</u>	
Across	Assessed %NBS before e'quakes: <u>100%</u>	#### %NBS from IEP below
	Assessed %NBS after e'quakes: <u>100%</u>	

If IEP not used, please detail assessment methodology: Equivalent Static

<b>Location</b>		Building Name: <input type="text" value="Ka Wahine Trust Halfway House"/>	Unit No: <input type="text" value="18"/>	Street: <input type="text" value="McGregors"/>	Reviewer: <input type="text" value="Mary Ann Halliday"/>
Building Address: <input type="text"/>	Legal Description: <input type="text"/>				CPEng No: <input type="text" value="67073"/>
			Company: <input type="text" value="Opus International Consultants"/>		
			Company project number: <input type="text" value="6-OC366.00"/>		
			Company phone number: <input type="text"/>		
			Date of submission: <input type="text" value="27-Feb-14"/>		
			Inspection Date: <input type="text" value="12/11/2013"/>		
			Revision: <input type="text" value="1"/>		
Building Unique Identifier (CCC): <input type="text" value="PRO2538"/>			Is there a full report with this summary? <input type="text" value="yes"/>		

<b>Site</b>	Site slope: <input type="text" value="flat"/>	Max retaining height (m): <input type="text"/>
	Soil type: <input type="text"/>	Soil Profile (if available): <input type="text"/>
	Site Class (to NZS1170.5): <input type="text" value="D"/>	
	Proximity to waterway (m, if <100m): <input type="text"/>	If Ground improvement on site, describe: <input type="text"/>
	Proximity to cliff top (m, if < 100m): <input type="text"/>	
	Proximity to cliff base (m,if <100m): <input type="text"/>	Approx site elevation (m): <input type="text"/>

<b>Building</b>	No. of storeys above ground: <input type="text" value="1"/>	single storey = 1	Ground floor elevation (Absolute) (m): <input type="text"/>
	Ground floor split?: <input type="text" value="no"/>		Ground floor elevation above ground (m): <input type="text"/>
	Storeys below ground: <input type="text" value="0"/>		
	Foundation type: <input type="text" value="bored cast-insitu concrete piles"/>		if Foundation type is other, describe: <input type="text"/>
	Building height (m): <input type="text" value="3.00"/>	height from ground to level of uppermost seismic mass (for IEP only) (m): <input type="text"/>	
	Floor footprint area (approx): <input type="text" value="106"/>		Date of design: <input type="text" value="1935-1965"/>
	Age of Building (years): <input type="text"/>		
	Strengthening present?: <input type="text" value="no"/>		If so, when (year)? <input type="text"/>
	Use (ground floor): <input type="text" value="multi-unit residential"/>		And what load level (%g)? <input type="text"/>
	Use (upper floors): <input type="text"/>		Brief strengthening description: <input type="text"/>
	Use notes (if required): <input type="text"/>		
	Importance level (to NZS1170.5): <input type="text" value="IL2"/>		

<b>Gravity Structure</b>	Gravity System: <input type="text" value="frame system"/>	rafter type, purlin type and cladding: <input type="text"/>
	Roof: <input type="text" value="timber framed"/>	joist depth and spacing (mm): <input type="text"/>
	Floors: <input type="text" value="timber"/>	overall depth x width (mm x mm): <input type="text"/>
	Beams: <input type="text" value="none"/>	typical dimensions (mm x mm): <input type="text"/>
	Columns: <input type="text" value="timber"/>	
	Walls: <input type="text" value="non-load bearing"/>	

<b>Lateral load resisting structure</b>	Lateral system along: <input type="text" value="lightweight timber framed walls"/>	<b>Note: Define along and across in detailed report!</b>	note typical wall length (m): <input type="text"/>
	Ductility assumed, μ: <input type="text" value="2.00"/>		estimate or calculation? <input type="text" value="estimated"/>
	Period along: <input type="text" value="0.10"/>	0.00	estimate or calculation? <input type="text"/>
	Total deflection (ULS) (mm): <input type="text"/>		estimate or calculation? <input type="text"/>
	maximum interstorey deflection (ULS) (mm): <input type="text"/>		
	Lateral system across: <input type="text" value="lightweight timber framed walls"/>		note typical wall length (m): <input type="text"/>
	Ductility assumed, μ: <input type="text" value="2.00"/>	0.00	estimate or calculation? <input type="text" value="estimated"/>
	Period across: <input type="text" value="0.10"/>		estimate or calculation? <input type="text"/>
	Total deflection (ULS) (mm): <input type="text"/>		estimate or calculation? <input type="text"/>
	maximum interstorey deflection (ULS) (mm): <input type="text"/>		

<b>Separations:</b>	north (mm): <input type="text"/>	leave blank if not relevant
	east (mm): <input type="text"/>	
	south (mm): <input type="text"/>	
	west (mm): <input type="text"/>	

<b>Non-structural elements</b>	Stairs: <input type="text"/>	describe (note cavity if exists): <input type="text"/>
	Wall cladding: <input type="text" value="brick or tile"/>	describe: <input type="text" value="red brick"/>
	Roof Cladding: <input type="text" value="Heavy tiles"/>	describe: <input type="text" value="concrete tiles"/>
	Glazing: <input type="text" value="timber frames"/>	
	Ceilings: <input type="text" value="strapped or direct fixed"/>	
	Services(list): <input type="text"/>	

<b>Available documentation</b>	Architectural: <input type="text" value="none"/>	original designer name/date: <input type="text"/>
	Structural: <input type="text" value="none"/>	original designer name/date: <input type="text"/>
	Mechanical: <input type="text" value="none"/>	original designer name/date: <input type="text"/>
	Electrical: <input type="text" value="none"/>	original designer name/date: <input type="text"/>
	Geotech report: <input type="text" value="none"/>	original designer name/date: <input type="text"/>

<b>Damage</b>	Site performance: <input type="text" value="Good"/>	Describe damage: <input type="text"/>
<b>Site:</b> (refer DEE Table 4-2)	Settlement: <input type="text" value="none observed"/>	notes (if applicable): <input type="text"/>
	Differential settlement: <input type="text" value="none observed"/>	notes (if applicable): <input type="text"/>
	Liquefaction: <input type="text" value="none apparent"/>	notes (if applicable): <input type="text"/>
	Lateral Spread: <input type="text" value="none apparent"/>	notes (if applicable): <input type="text"/>
	Differential lateral spread: <input type="text" value="none apparent"/>	notes (if applicable): <input type="text"/>
	Ground cracks: <input type="text" value="none apparent"/>	notes (if applicable): <input type="text"/>
	Damage to area: <input type="text" value="none apparent"/>	notes (if applicable): <input type="text"/>

<b>Building:</b>	Current Placard Status: <input type="text" value="green"/>	
<b>Along</b>	Damage ratio: <input type="text" value="0%"/>	Describe how damage ratio arrived at: <input type="text"/>
	Describe (summary): <input type="text"/>	
<b>Across</b>	Damage ratio: <input type="text" value="0%"/>	$Damage\_Ratio = \frac{(\%NBS\ (before) - \%NBS\ (after))}{\%NBS\ (before)}$
	Describe (summary): <input type="text"/>	
<b>Diaphragms</b>	Damage?: <input type="text" value="yes"/>	Describe: <input type="text"/>
<b>CSWs:</b>	Damage?: <input type="text" value="no"/>	Describe: <input type="text"/>
<b>Pounding:</b>	Damage?: <input type="text" value="no"/>	Describe: <input type="text"/>
<b>Non-structural:</b>	Damage?: <input type="text" value="yes"/>	Describe: <input type="text"/>

<b>Recommendations</b>	Level of repair/strengthening required: <input type="text" value="minor non-structural"/>	Describe: <input type="text"/>
	Building Consent required: <input type="text" value="no"/>	Describe: <input type="text"/>
	Interim occupancy recommendations: <input type="text" value="full occupancy"/>	Describe: <input type="text"/>
<b>Along</b>	Assessed %NBS before e'quakes: <input type="text" value="100%"/>	#### %NBS from IEP below
	Assessed %NBS after e'quakes: <input type="text" value="100%"/>	If IEP not used, please detail assessment methodology: <input type="text" value="Equivalent Static"/>
<b>Across</b>	Assessed %NBS before e'quakes: <input type="text" value="100%"/>	#### %NBS from IEP below
	Assessed %NBS after e'quakes: <input type="text" value="100%"/>	



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