

*Christchurch City Council*

# **Glue Place Housing Complex PRO 1097**

**Detailed Engineering Evaluation  
Quantitative Assessment Report**





*Christchurch City Council*

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# **Glue Place Housing Complex**

## **Quantitative Assessment Report**

**Glue Place, Hoon Hay, Christchurch  
8024**

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# Summary

Glue Place Housing Complex  
PRO 1097

Detailed Engineering Evaluation  
Quantitative Report - Summary  
Final

## Background

This is a summary of the quantitative report for the Glue 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 35 residential units.

## Key Damage Observed

The residential units suffered minor damage to non-structural elements

Structural damage to the residential units was generally minor and was limited to the cracking of the wall and ceiling linings.

## Level Survey

All floor slopes assessed, with the exception of unit 17, were less than the 5mm/m limitation set out in the MBIE guidelines [6]. Unit 17 has a slope of 14mm/m.

## Critical Structural Weaknesses

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

## Indicative Building Strength

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

The standard residential units have a capacity of 72%NBS and the altered Block G (4, 6 and 8 Sparks Road) has a capacity of 84%NBS. Both building types are limited by the in-plane shear capacity of the timber-framed walls in the longitudinal direction.

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

Block	NBS%
PRO 1097 Boo1	72%
PRO 1097 Boo2	72%
PRO 1097 Boo3	72%
PRO 1097 Boo4	72%
PRO 1097 Boo5	72%
PRO 1097 Boo6	72%
PRO 1097 Boo7	84%
PRO 1097 Boo8	72%
PRO 1097 Boo9	72%

## Recommendations

It is recommended that unit 17 is re-levelled and cosmetic repair works to cracks in walls and foundations are undertaken.

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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 Glue Place Housing Complex, located at the intersection of Lyttelton Street and Sparks Road, Somerfield, Christchurch, following the Canterbury Earthquake Sequence since September 2010. The site was visited by Opus International Consultants on 25 June 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	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 Cordonning

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 35 residential units which were constructed in 1961 and were refurbished in 1991-97. The units are numbered 1 to 33 (there is no unit 13, 26, 28, 30 or 32 and two units numbered 4, 6, 8, 12, 14, 16 and 18) the double up on unit numbers at the rear of the section is due to those units being addressed to Sparks Road rather than Glue Place. The units are grouped together to form 8 blocks of 4 units and 1 block of 3 units. A site plan showing the locations of the units is shown in Figure 2. Figure 3 shows the location of the site in Christchurch City.

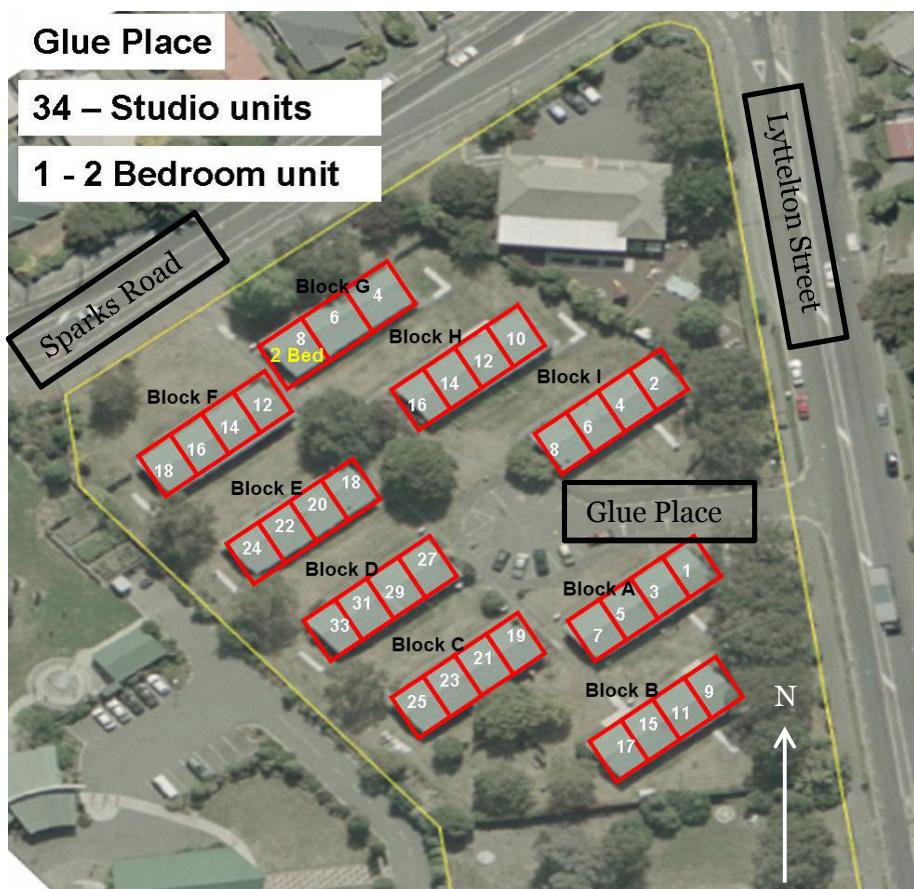
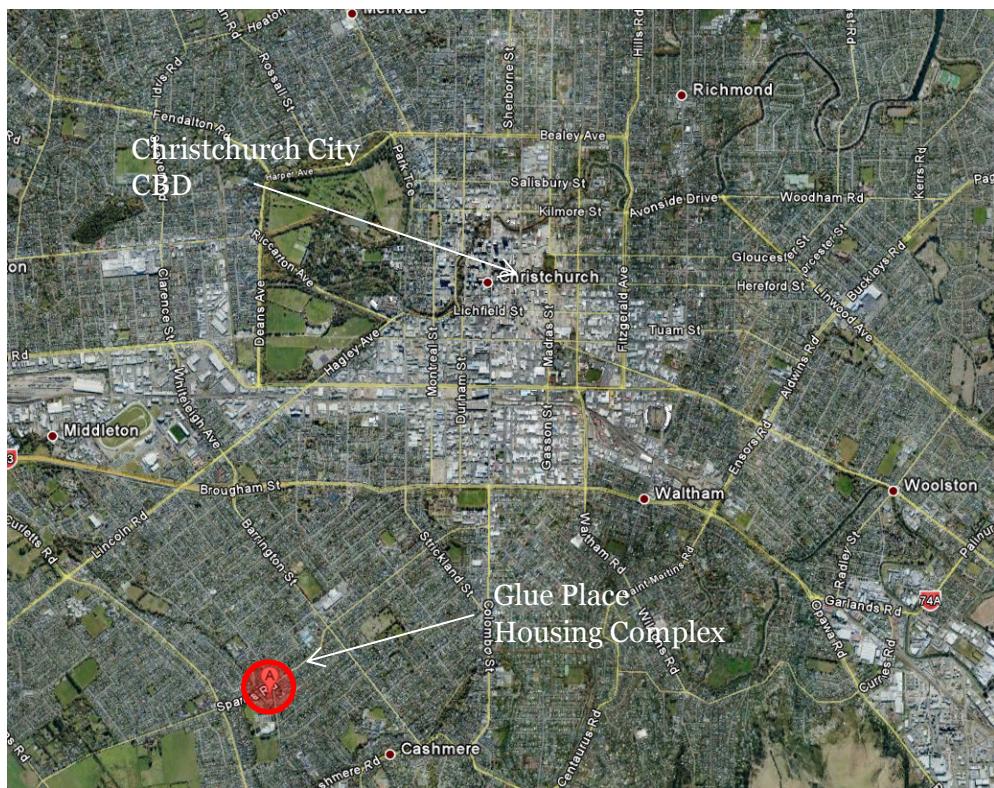


Figure 2: Site plan of Glue Place Housing Complex.



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

The residential units are timber-framed buildings with timber braces in the walls. The roof structure is timber purlins and rafters supporting light-weight metal roofs. The ceiling follows the pitch of the roof leaving only a very small (1.4m wide), inaccessible ceiling space. Walls and ceilings are lined with GIB and GIB/pinex respectively. Cladding above and below windows is light-weight Harditex-type cladding with the remaining wall areas clad with brick veneer. Foundations consist of a concrete perimeter wall with concrete piles, timber bearers/joists and tongue and groove floor boards. The units are separated by 230mm thick double brick fire walls. A chimney was built as an integral part of the fire wall. This has been removed above the roof lines and boarded up in the lounge.

Figure 4 shows a typical cross section of a unit and Figure 5 shows a typical partial floor plan of a block of residential units produced from site measurements by Opus.

Figure 6 shows the alternative layout of the altered units located at 4-8 Sparks Road. This block has similar construction to the typical blocks of units on the site. It has been altered to merge two of the units into a two-bedroom unit and extend the living area of the remaining two single-bedroom units.

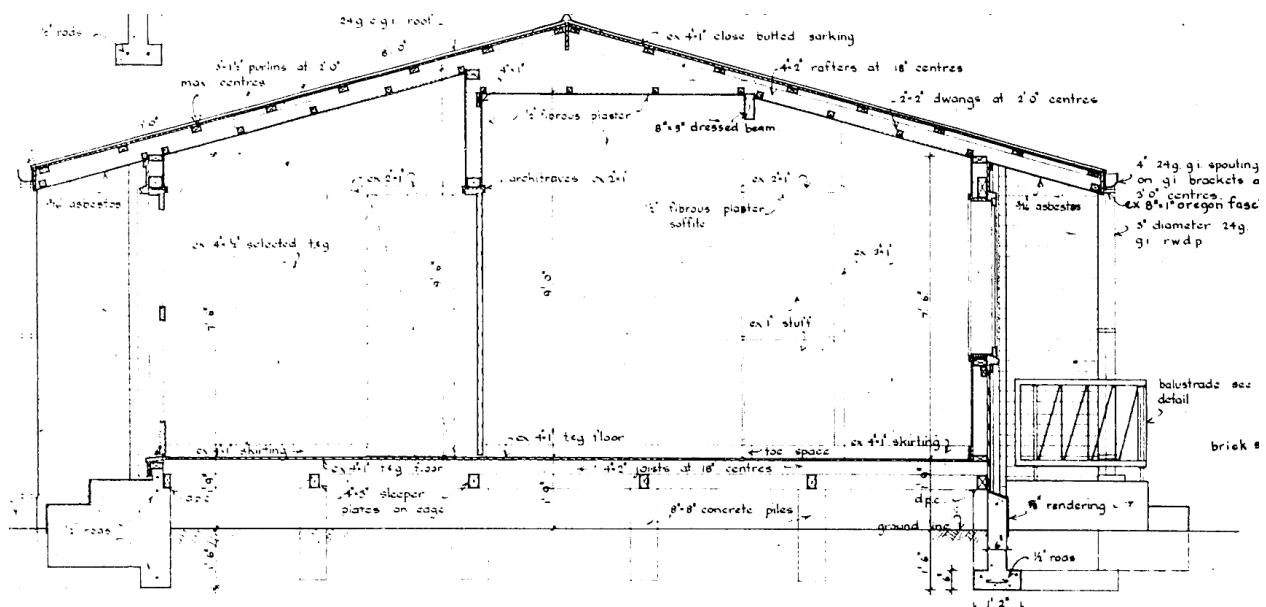


Figure 4: Typical cross section of a residential unit

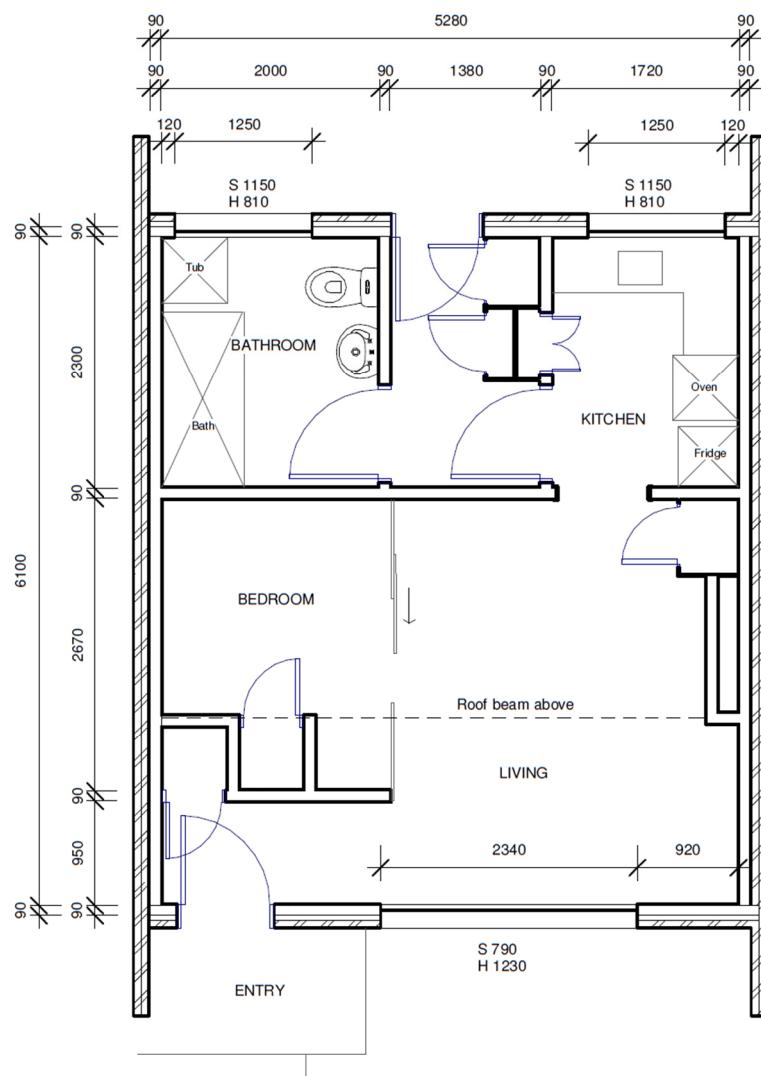
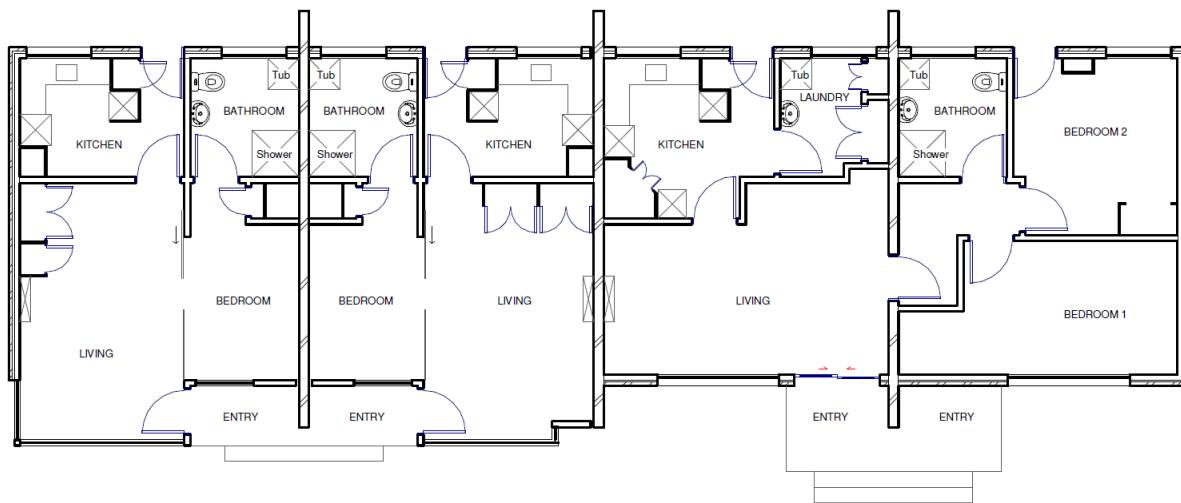


Figure 5: Partial floor plan of residential unit blocks.



**Figure 6: Floor plan of the altered units at 4, 6 and 8 Sparks Road.**

#### 4.1.1 Post 22 February 2011 Rapid Assessment

A structural (Level 1) assessment of the buildings/property was undertaken on May 8<sup>th</sup>, 2011 by Opus International Consultants. Minor cracking was observed in the interior GIB lining of most units and in exterior building veneers.

#### 4.1.2 Further Inspections

A structural (Level 2) assessment of units 10 and 12 was undertaken on March 17<sup>th</sup>, 2011 by Opus International Consultants. These units were observed during the Level 1 assessment to have suffered the greatest damage.

#### 4.1.3 Level Survey

A full level survey was not deemed to be necessary at Glue Place Housing Complex as it is located in a TC2 zone (Figure 10). Properties in TC2 zones suffered minor to moderate amounts of 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. The slope in unit 17 was 14mm/m (which exceeds the 5mm/m limitation imposed by MBIE [6]) as shown in Figure 7. This was an isolated case and no other units exceeded the 5mm/m limit.

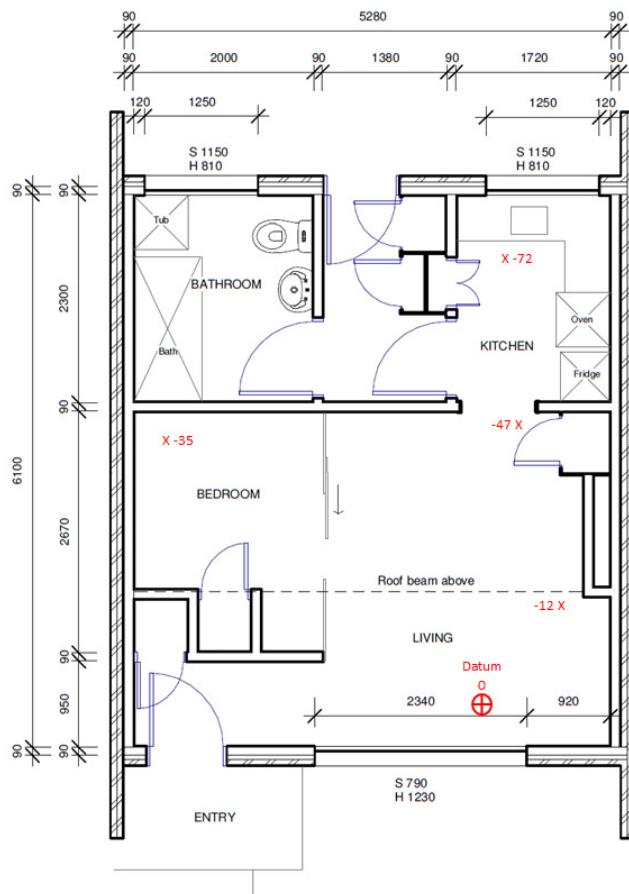


Figure 7: Results of laser level survey from unit 17

## 4.2 Original Documentation

Copies of the following construction drawings were provided by CCC:

- Plans, elevations, sections and details for the original construction of the units.
- CCC Job No. 11252 Glue Place – Proposed E.P.H Alterations Plans - 23/1/1991 (These alteration plans include details of the conversion of two units into a two bedroom unit at 8 Sparks Road).

The drawings have been used to confirm the structural systems, investigate potential critical structural weaknesses (CSW) and identify details which required particular attention.

Copies of the design calculations were not provided.

## 5 Structural Damage

This section outlines the damage to the buildings (as of 25 June 2013) 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

The results of the level survey show that the floor in unit 17 is 72mm out of level. This indicates the possibility of ground settlement. This unit showed no more damage than the other units internally. The doors and windows in the unit had been planed prior to the earthquake indicating that the displacement is likely to be historical. Foundation damage consistent with this movement is shown in photo 11.

## 5.2 Foundations

Minor cracking (less than 1mm) in the concrete perimeter foundation walls (photo 4). This damage was common throughout all the units.

## 5.3 Primary Gravity Structure

No damage to the primary gravity structure was observed.

## 5.4 Primary Lateral-Resistance Structure

Minor cracking to the GIB wall linings was observed in most units, especially above window and door openings.

## 5.5 Non Structural Elements

Minor step cracking in the brick veneers was observed throughout all the units (photo 5).

Damage to the roof cladding due to movement of the fire walls (photo 3) was observed in all units.

## 5.6 General Observations

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

# 6 Detailed Seismic Assessment

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

As the majority of the residential units have the same floor plan, the analysis was simplified by conducting the analysis of each multi-unit block once for each cladding type. The units at 4, 6 and 8 Sparks Road were analysed separately.

## 6.1 Critical Structural Weaknesses

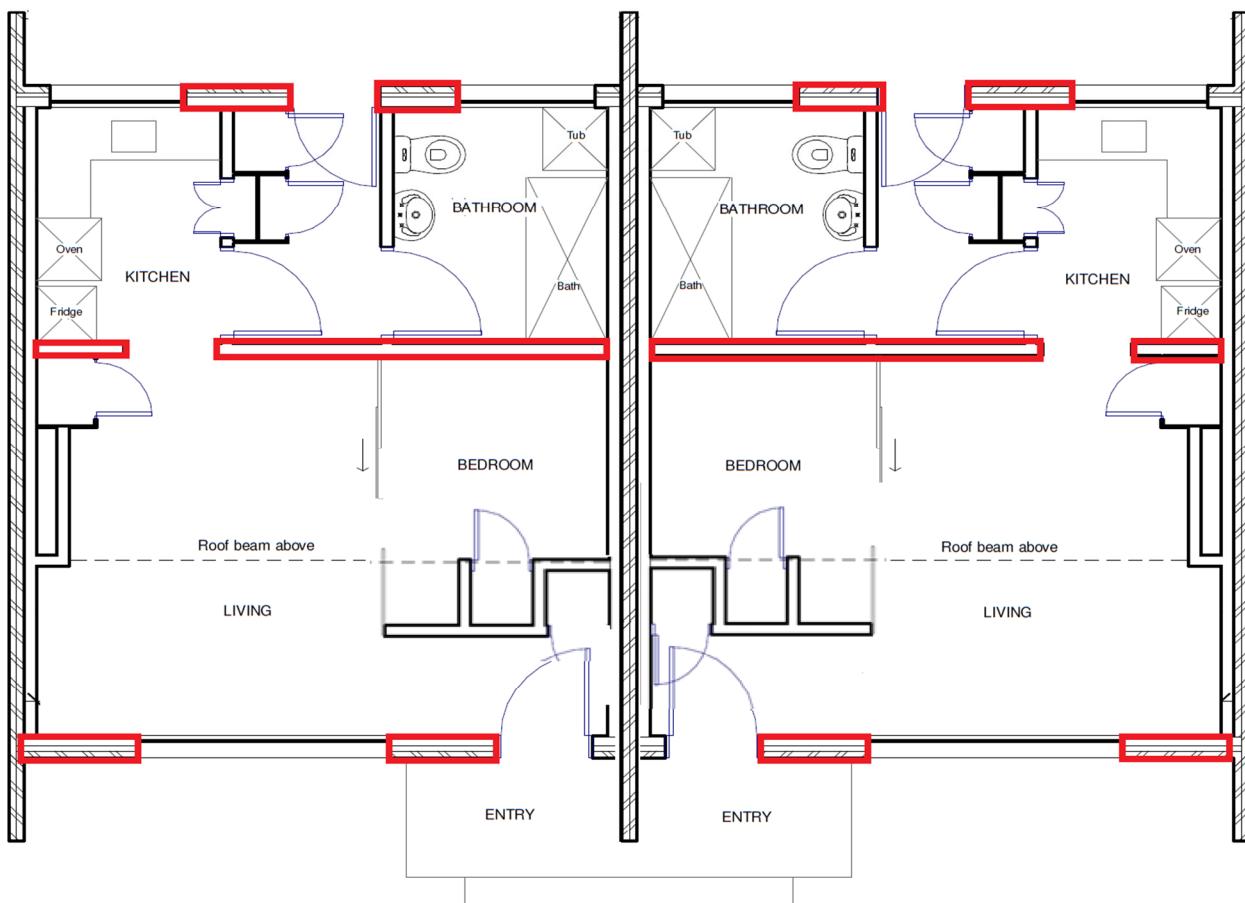
The term Critical Structural Weakness (CSW) refers to a component of a building that could contribute to increased levels of damage or cause premature collapse of a building. During the initial qualitative stage of the assessment the following potential CSW's were identified for each of the buildings and have been considered in the quantitative analysis.

No CSWs were identified in the buildings.

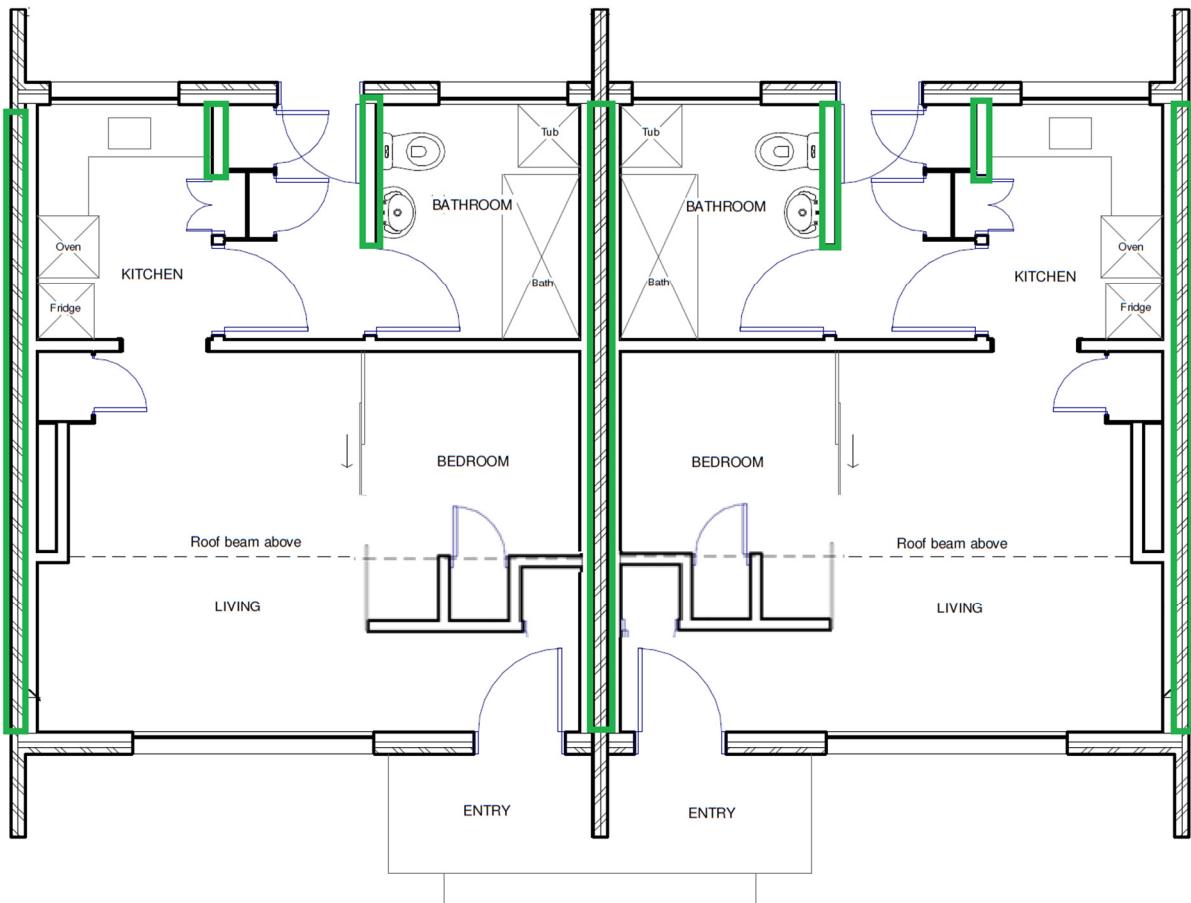
## 6.2 Quantitative Assessment Methodology

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

Hand calculations were performed to determine seismic forces from the current building codes. These forces were applied globally to the structure and the capacities of the walls were calculated and used to estimate the %NBS. The walls, highlighted in Figure 8 and Figure 9, were used for bracing in their respective directions.



**Figure 8: Walls used for bracing in the longitudinal direction**



**Figure 9: 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

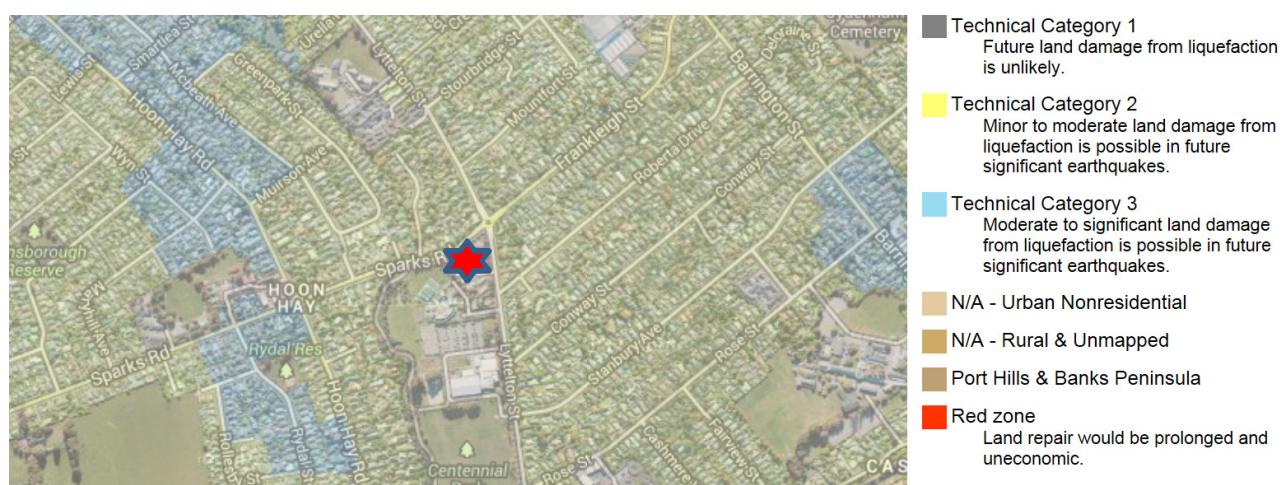
A summary of the structural performance of the buildings is shown in Table 2. Note that the values given represent the worst performing elements in the building, where these effectively define the building's capacity. Other elements within the building may have significantly greater capacity when compared with the governing elements.

**Table 2: Summary of Seismic Performance**

Building	Critical Element	% NBS in the longitudinal direction.	% NBS in the transverse direction.
Blocks A-F, H & I	In-plane shear strength of bracing walls	72%	100%
Block G	In-plane shear strength of bracing walls	84%	100%

## 7 Summary of Geotechnical Appraisal

CERA indicates that Glue Place Housing Complex is located in a TC2 zone (as shown in Figure 10). This classification suggests future significant earthquakes will cause minor to moderate land damage due to liquefaction and settlement.



**Figure 10: CERA Technical Categories map (location starred)**

A geotechnical site visit was conducted by Opus on 17 March 2011. This showed evidence of ejected material due to liquefaction and damage to units 10 and 12 predominantly caused by a burst water main [7].

In the June 2013 site visit it was noted that the ground on the opposite side of the fence adjacent to unit 17 was about half a metre lower. This suggests that the unit may have been placed on fill to level the section. Settlement of this fill would be consistent with the levels found in this unit. Hand augers as part of a geotechnical site investigation could confirm the presence of fill.

Should the client wish to further develop this site, a full geotechnical investigation and report is recommended.

## 8 Conclusions

- None of the buildings on site are considered to be Earthquake Prone.
- The unaltered residential units have capacities of 72% 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 2-5 times that of a 100% NBS building (Figure 1).
- The altered residential Block G, at 4, 6 and 8 Sparks Road, has a capacity of 84% 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 1-2 times that of a 100% NBS building (Figure 1).

## 9 Recommendations

It is recommended that unit 17 is re-levelled and cosmetic repair works to cracks in walls and foundations are undertaken.

## 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 Glue 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.
- [7] Walker, Kelly (2011), Glue Place – Geotechnical Site Visit, Opus International Consultants, March 2011.

## **Appendix A - Photographs**

**Glue Place Housing Complex – Detailed Engineering Evaluation**

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Glue Place Housing Complex		
Residential Units		
1	Typical block	
2	Typical unit	

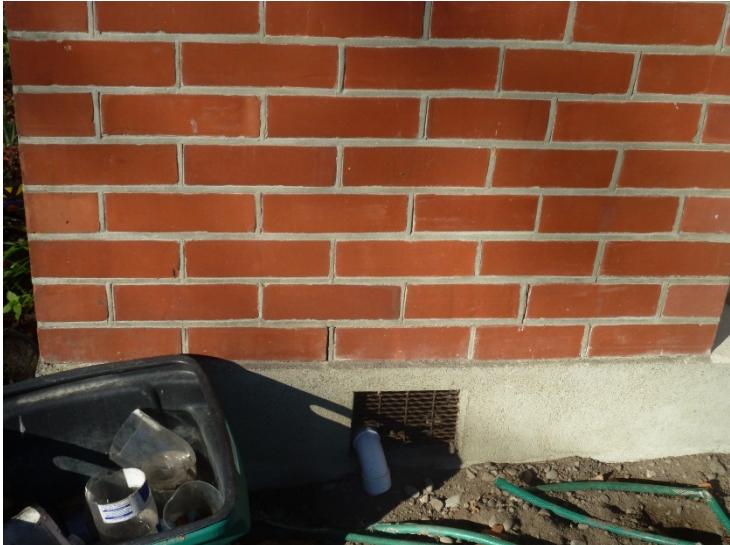
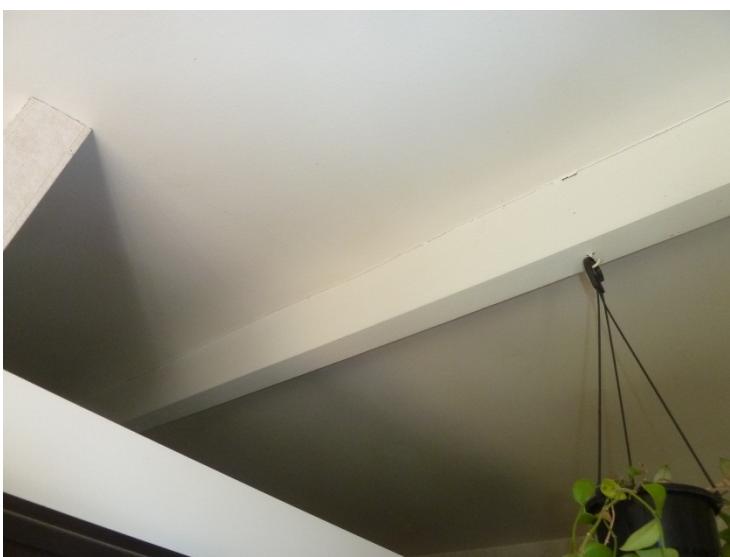
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3	Damage to the roof cladding due to movement of fire wall relative to the rest of the structure.	
4	Cracking in concrete foundations (all units)	
5	Stepped cracking seen in exterior brick veneer cladding (most units)	

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6	Loose and cracked mortar between brick cladding common (most units)	
7	Cracking from corner of window (several units)	
8	Cracking where beam meets ceiling cladding (most units)	

9	Cracking between GIB ceiling and wall linings (most units)	
10	Cracking where GIB wall linings joins (some units)	
11	Foundation damage unit 17	

## **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.

## Analysis Procedure

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

## Additional Assumptions

Further assumptions about the seismic performance of the buildings were:

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

## **Appendix C - CERA DEE Spreadsheet**

<b>Location</b>		Building Name: <input type="text" value="Glue Place Housing Complex"/>	Unit No: <input type="text" value="Street"/>	Reviewer: <input type="text" value="Mary Ann Halliday"/>
		Building Address: <input type="text" value="Units at 4,6, and 8 Sparks Road"/>	Glue Place	CPEng No: <input type="text" value="67073"/>
		Legal Description: <input type="text" value="Residential Units"/>		Company: <input type="text" value="OPUS International Consultants Ltd"/>
		GPS south: <input type="text" value="-43.56399847"/>	Degrees <input type="text" value=""/>	Company project number: <input type="text" value="6-QC346.00"/>
		GPS east: <input type="text" value="172.6140769"/>	Min <input type="text" value=""/>	Company phone number: <input type="text" value="6433635400"/>
		Building Unique Identifier (CCC): <input type="text" value="PRO 1097"/>	Sec <input type="text" value=""/>	Date of submission: <input type="text" value="Aug-13"/>
				Inspection Date: <input type="text" value="25-Jun-13"/>
				Revision: <input type="text" value="Final"/>
				Is there a full report with this summary? <input type="checkbox"/>
<b>Site</b> Site slope: <input type="text"/> Soil type: <input type="text"/> Site Class (to NZS1170.5): <input type="text" value="99"/> Proximity to waterway (m, if <100m): <input type="text"/> Proximity to clifftop (m, if <100m): <input type="text"/> Proximity to cliff base (m,if <100m): <input type="text"/> Max retaining height (m): <input type="text"/> Soil Profile (if available): <input type="text"/> If Ground improvement on site, describe: <input type="text"/> Approx site elevation (m): <input type="text" value="1.00"/>				
<b>Building</b> No. of storeys above ground: <input type="text" value="1"/> single storey = 1 Ground floor split? <input type="checkbox"/> no Storeys below ground: <input type="text" value="0"/> Foundation type: <input type="text" value="isolated pads, no tie beams"/> Building height (m): <input type="text"/> Floor footprint area (approx): <input type="text"/> Age of Building (years): <input type="text" value="52"/> Ground floor elevation (Absolute) (m): <input type="text"/> Ground floor elevation above ground (m): <input type="text"/> If Foundation type is other, describe: <input type="text"/> height from ground to level of uppermost seismic mass (for IEP only) (m): <input type="text"/> Date of design: <input type="text" value="1935-1965"/> Strengthening present? <input type="text"/> If so, when (year)? <input type="text"/> And what load level (%g)? <input type="text"/> Use (ground floor): <input type="text" value="multi-unit residential"/> Use (upper floors): <input type="text"/> Use notes (if required): <input type="text"/> Brief strengthening description: <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"/> Roof: <input type="text" value="timber framed"/> Floors: <input type="text" value="timber"/> Beams: <input type="text" value="timber"/> Columns: <input type="text"/> Walls: <input type="text"/> rafter type, purlin type and cladding joist depth and spacing (mm) type <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>				
<b>Lateral load resisting structure</b> Lateral system along: <input type="text" value="lightweight timber framed walls"/> Ductility assumed, $\mu$ : <input type="text" value="2.00"/> Period along: <input type="text" value="0.10"/> Total deflection (ULS) (mm): <input type="text"/> maximum interstorey deflection (ULS) (mm): <input type="text"/> Note: Define along and across in detailed report! 0.00 note typical wall length (m) estimate or calculation? <input type="text" value="estimated"/> estimate or calculation? <input type="text"/> estimate or calculation? <input type="text"/>  Lateral system across: <input type="text" value="lightweight timber framed walls"/> Ductility assumed, $\mu$ : <input type="text" value="2.00"/> Period across: <input type="text" value="0.10"/> Total deflection (ULS) (mm): <input type="text"/> maximum interstorey deflection (ULS) (mm): <input type="text"/> note typical wall length (m) estimate or calculation? <input type="text" value="estimated"/> estimate or calculation? <input type="text"/> estimate or calculation? <input type="text"/>				
<b>Separations:</b> north (mm): <input type="text"/> east (mm): <input type="text"/> south (mm): <input type="text"/> west (mm): <input type="text"/> leave blank if not relevant				
<b>Non-structural elements</b> Stairs: <input type="text"/> Wall cladding: <input type="text" value="brick or tile"/> Roof Cladding: <input type="text" value="Metal"/> Glazing: <input type="text" value="aluminum frames"/> Ceilings: <input type="text" value="strapped or direct fixed"/> Services(list): <input type="text"/> describe (note cavity if exists) <input type="text"/> describe <input type="text" value="lightweight"/> <input type="text"/> <input type="text"/>				
<b>Available documentation</b> Architectural: <input type="text" value="partial"/> Structural: <input type="text" value="none"/> Mechanical: <input type="text" value="none"/> Electrical: <input type="text" value="none"/> Geotech report: <input type="text"/> original designer name/date <input type="text" value="1960"/> original designer name/date <input type="text"/> original designer name/date <input type="text"/> original designer name/date <input type="text"/> original designer name/date <input type="text"/>				
<b>Damage</b> Site: <input type="text"/> (refer DEE Table 4-2) Site performance: <input type="text"/> Describe damage: <input type="text"/>  Settlement: <input type="text"/> Differential settlement: <input type="text"/> Liquefaction: <input type="text"/> Lateral Spread: <input type="text"/> Differential lateral spread: <input type="text"/> Ground cracks: <input type="text"/> Damage to area: <input type="text"/> notes (if applicable): <input type="text"/>				
<b>Building:</b> Current Placard Status: <input type="text" value="green"/>  Along: Damage ratio: <input type="text" value="0%"/> Describe (summary): <input type="text"/> Describe how damage ratio arrived at: <input type="text"/>  Across: Damage ratio: <input type="text" value="0%"/> Describe (summary): <input type="text"/> $\text{Damage Ratio} = \frac{(\% \text{NBS (before)} - \% \text{NBS (after)})}{\% \text{NBS (before)}}$  Diaphragms: Damage?: <input type="checkbox"/> no Describe: <input type="text"/>  CSWs: Damage?: <input type="checkbox"/> no Describe: <input type="text"/>  Pounding: Damage?: <input type="checkbox"/> no Describe: <input type="text"/>  Non-structural: Damage?: <input type="checkbox"/> yes Describe: <input type="text" value="minor GIB cracking"/>				
<b>Recommendations</b> Level of repair/strengthening required: <input type="text"/> Building Consent required: <input type="text"/> Interim occupancy recommendations: <input type="text"/>  Along: Assessed %NBS before e'quakes: <input type="text" value="84%"/> ##### %NBS from IEP below Assessed %NBS after e'quakes: <input type="text" value="84%"/>  Across: 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 Quantitative assessment methodology: <input type="text"/>				

<b>Location</b>		Building Name: <input type="text" value="Glue Place Housing Complex"/> Unit No: <input type="text" value="Street"/>	Reviewer: <input type="text" value="Mary Ann Halliday"/> CPEng No: <input type="text" value="67073"/>
		Building Address: <input type="text" value="Units 1-33 (Excluding units at 4,6, and 8 Sparks Rd Glue Place"/> Legal Description: <input type="text" value="Residential Units"/>	Company: <input type="text" value="OPUS International Consultants Ltd"/> Company project number: <input type="text" value="6-QC346.00"/>
		GPS south: <input type="text" value="-43.56399847"/> Degrees <input type="text"/> Min <input type="text"/> Sec GPS east: <input type="text" value="172.6140769"/>	Company phone number: <input type="text" value="6433635400"/>
		Date of submission: <input type="text" value="Aug-13"/> Inspection Date: <input type="text" value="25-Jun-13"/> Revision: <input type="text" value="Final"/>	Is there a full report with this summary? <input type="checkbox"/>
		Building Unique Identifier (CCC): <input type="text" value="PRO 1097"/>	
<b>Site</b> Site slope: <input type="text"/> Soil type: <input type="text"/> Site Class (to NZS1170.5): <input type="text" value="99"/> Proximity to waterway (m, if <100m): <input type="text"/> Proximity to clifftop (m, if <100m): <input type="text"/> Proximity to cliff base (m,if <100m): <input type="text"/> Max retaining height (m): <input type="text"/> Soil Profile (if available): <input type="text"/> If Ground improvement on site, describe: <input type="text"/> Approx site elevation (m): <input type="text" value="1.00"/>			
<b>Building</b> No. of storeys above ground: <input type="text" value="1"/> single storey = 1 Ground floor split? <input type="checkbox"/> no Storeys below ground: <input type="text" value="0"/> Foundation type: <input type="text" value="isolated pads, no tie beams"/> Building height (m): <input type="text"/> Floor footprint area (approx): <input type="text"/> Age of Building (years): <input type="text" value="52"/> Ground floor elevation (Absolute) (m): <input type="text"/> Ground floor elevation above ground (m): <input type="text"/> If Foundation type is other, describe: <input type="text"/> height from ground to level of uppermost seismic mass (for IEP only) (m): <input type="text"/> Date of design: <input type="text" value="1935-1965"/> Strengthening present? <input type="text"/> If so, when (year)? <input type="text"/> And what load level (%g)? <input type="text"/> Use (ground floor): <input type="text" value="multi-unit residential"/> Use (upper floors): <input type="text"/> Use notes (if required): <input type="text"/> Brief strengthening description: <input type="text"/> Importance level (to NZS1170.5): <input type="text" value="IL2"/>			
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<b>Separations:</b> north (mm): <input type="text"/> east (mm): <input type="text"/> south (mm): <input type="text"/> west (mm): <input type="text"/> leave blank if not relevant			
<b>Non-structural elements</b> Stairs: <input type="text"/> Wall cladding: <input type="text" value="brick or tile"/> Roof Cladding: <input type="text" value="Metal"/> Glazing: <input type="text" value="aluminium frames"/> Ceilings: <input type="text" value="strapped or direct fixed"/> Services(list): <input type="text"/> describe (note cavity if exists) <input type="text"/> describe <input type="text" value="lightweight"/>			
<b>Available documentation</b> Architectural: <input type="text" value="partial"/> Structural: <input type="text" value="none"/> Mechanical: <input type="text" value="none"/> Electrical: <input type="text" value="none"/> Geotech report: <input type="text"/> original designer name/date <input type="text" value="1960"/> original designer name/date <input type="text"/> original designer name/date <input type="text"/> original designer name/date <input type="text"/> original designer name/date <input type="text"/>			
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<b>Recommendations</b> Level of repair/strengthening required: <input type="text"/> Building Consent required: <input type="text"/> Interim occupancy recommendations: <input type="text"/>  Along: Assessed %NBS before e'quakes: <input type="text" value="72% ##### %NBS from IEP below"/> Assessed %NBS after e'quakes: <input type="text" value="72%"/>  Across: 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 Quantitative assessment methodology: <input type="text"/>			



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