Christchurch City Council

Elmwood Park Tool Shed
PRK 0590 BLDG 003 EQ2

Detailed Engineering Evaluation

Quantitative Assessment Report

Christchurch City Council

Elmwood Park Tool Shed Quantitative Assessment Report

Prepared By

Timothy Day
Graduate Structural Engineer

Reviewed By

Simon Biggs
Structural Engineer

Approved for Release By

Alistair Boyce
Senior Structural Engineer
CPEng 209860

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

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

Date: 7 February 2013
Reference: 6-QUCC1.52
Status: Final

Summary

Elmwood Park Tool Shed
PRK 0590 BLDG 003 EQ2

Detailed Engineering Evaluation
Quantitative Report - Summary
Final

Background
This is a summary of the quantitative report for the Elmwood Park Tool Shed building, and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011 and visual inspections on the 21 June, 10 September & 17 October 2012.

Key Damage Observed
No seismic damage was identified at the time of inspection.

Critical Structural Weaknesses
No potential critical structural weaknesses have been identified.

Indicative Building Strength
Based on the information available, and from undertaking a quantitative assessment, the building's seismic capacity has been assessed as 54%NBS.

The structure has been assessed to have seismic capacities of more than 33%NBS, and is therefore not classed as an earthquake prone building under the NZSEE classification system.

As the building has a capacity of between 33%NBS and 67%NBS it is defined as a moderate earthquake risk building under the NZSEE classification system and has a relative risk of failure of 5-10 times that of a building constructed to the New Building Standard. Based on the form of construction and the seismic load resisting systems present we do not believe that the building has a high risk of collapse. It is therefore considered that there is not a high risk imposed to building occupants.

Recommendations
We make the following recommendations:

a) It is recommended that the unreinforced masonry walls be strengthened to improve the buildings structural performance to at least 67% NBS in accordance with the Royal Commission final report recommendations.

b) Additional investigations should be undertaken to determine the method and adequacy of the fixing of the ceiling diaphragm to the block walls, and the extent of the vertical starter bar reinforcing,

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council to undertake a detailed seismic assessment of the Elmwood Park Tool Shed, located at Heaton Street, Strowan, Christchurch following the Canterbury Earthquake Sequence since September 2010.

The purpose of the assessment is to determine if the building is 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) [3] [4].

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 2006. This policy was amended immediately following the Darfield Earthquake on 4 September 2010.

The 2010 amendment 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

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

Table 1: %NBS compared to relative risk of failure

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

3.1 Minimum and Recommended Standards

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

3.1.1 Occupancy

The Canterbury Earthquake Order[1] in Council 16 September 2010, modified the meaning of "dangerous building" to include buildings that were identified as being EPB's. As a result of this, we would expect such a building would be issued with a Section 124 notice, by the Territorial Authority, or CERA acting on their behalf, once they are made aware of our assessment. Based on information received from CERA to date and from the DBH guidance document dated 12 June 2012 [6], this notice is likely to prohibit occupancy of the building (or parts thereof), until its seismic capacity is improved to the point that it is no longer considered an EPB.

3.1.2 Cordoning

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

3.1.3 Strengthening

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

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

3.1.4 Our Ethical Obligation

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

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

4 Background Information

4.1 Building Description

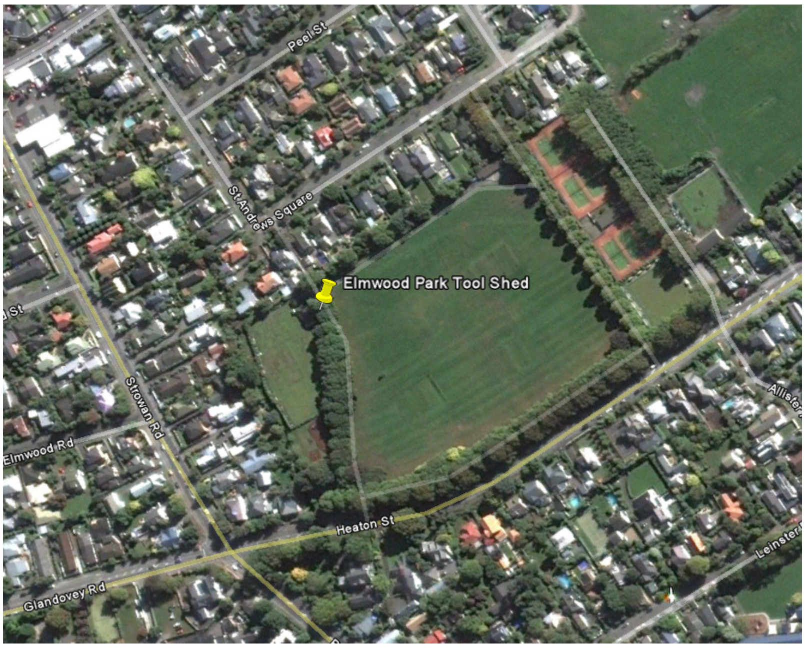

Figure 2 - Location of Elmwood Park Tool Shed

The Elmwood Park Tool Shed is a single storey unreinforced masonry building with a lightweight low pitched corrugated iron roof. The floor is a concrete slab-on-grade.

The 9m long by 4m wide building is situated on relatively flat ground near the edge of the park. The roof apex height is approximately 3.3m above slab level.

All walls are 2.5m high running bond 20 series (190mm wide) concrete masonry. All block walls have one row (100mm high) of Summerhill stone running mid-height.

4.2 Survey

Visual inspections were carried out on the 21 June 2012, 10 September 2012 and 17 October 2012.

The building currently has no earthquake rapid assessment placard in place.

No copies of structural drawings have been obtained for the building. Our measure up and observations have been used to confirm the structural systems, to investigate potential critical structural weaknesses (CSW's) wherever possible, and identify details which would require particular attention.

The survey indicated that the concrete blocks are 20 series (190mm wide). From a cover meter survey no reinforcement bars were identified in the walls except in the concrete masonry lintels spanning over the doors, and irregular starter bars into the concrete block work at approximately 600 centres.

No other vertical bars were found from our cover meter survey and a drill test showed the blocks to be ungrouted.

4.3 Original Documentation

No construction drawings or design calculations for the structure were located for this building.

5 Structural Damage

The structure shows some minor cracking by the decorative blocks. We also observed three of the four corner locations have hairline zigzag cracks near the edge. It is deemed that these cracks are a result of age, usage and long term movement and not from recent earthquake damage.

6 General Observations

Overall the building has performed well under seismic conditions despite essentially being an unreinforced masonry building. The building has sustained no apparent damage and continues to be fully operational.

Due to the non-intrusive nature of the original survey, not all structural details could be ascertained, such as the connection of the diaphragm ceiling to block walls.

7 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 18 September 2012.

7.1 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.

We have not identified any critical structural weaknesses with this building.

7.2 Seismic coefficient comparison

The seismic design parameters based on current design requirements from NZS1170.5:2004 and the NZBC clause B1 for this building are:

- Site soil class D, clause 3.1.3 NZS 1170.5:2004;

- Site hazard factor, Z=0.3, B1/VM1 clause 2.2.14B;
- Return period factor, Ru = 1.0 from Table 3.5, NZS 1170.5:2004, for an Importance Level 2 structure with a 50 year design life;
- Structural Ductility Factor, μ_{max} = 1.0 based on unreinforced masonry

7.3 Quantitative Assessment Methodology

The assessment analysis has been based on assumed material properties for unreinforced concrete masonry.

The assessment assumed that the total seismic load would be distributed by the flexible ceiling diaphragm to the unreinforced block walls in proportion to the wall's tributary roof support area, so that all walls are acting in-plane.

7.4 Limitations and Assumptions in Results

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

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

7.5 Assessment

A summary of the structural performance of the building is shown in the following tables. Note that the values given represent the worst performing elements in the building, as 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 – μ = 1.0**

Structural Element/System	Failure mode	% NBS based on calculated capacity
Unreinforced concrete block walls across	In-plane diagonal tension in unreinforced masonry	100% NBS
Unreinforced concrete block walls	Our-of-plane capacity of unreinforced masonry	54% NBS

The building has a seismic capacity of 54% NBS as governed by the out of plane capacity of the unreinforced concrete block walls, and is therefore not considered to be an earthquake prone building. In line with NZSEE guidelines it is classified as a moderate earthquake risk building.

Although the building has not been damaged in the earthquakes and we have determined that it has adequate seismic capacity, consideration should be made on whether a seismic retrofit would nevertheless be appropriate for an unreinforced masonry building in line with the Royal Commission final report recommendations. Additional investigations of this building should be undertaken to determine the method and adequacy of the fixing of the ceiling diaphragm to the block walls, and the extent of starter bar reinforcing from the foundations into the walls.

8 Geotechnical

No specific geotechnical assessment has been undertaken for this site due to the lack of observed ground damage. The site parameters used for the structural analysis have been taken as site subsoil class D, based on geotechnical advice.

9 Conclusions

a) The building has a seismic capacity of 54% NBS and is therefore not classed as an earthquake prone building under the NZSEE classification system.

b) As the building has a capacity of between 33%NBS and 67%NBS it is defined as a moderate earthquake risk building under the NZSEE classification system and has a relative risk of failure of 5-10 times that of a building constructed to the New Building Standard. Based on the form of construction and the seismic load resisting systems present we do not believe that the building has a high risk of collapse. It is therefore considered that there is not a high risk imposed to building occupants.

c) The existing foundations have performed satisfactorily, and no geotechnical testing is required.

10 Recommendations

We make the following recommendations:

a) It is recommended that the unreinforced masonry walls be strengthened to improve the buildings structural performance to at least 67% NBS in accordance with the Royal Commission final report recommendations.

b) Additional investigations should be undertaken to determine the method and adequacy of the fixing of the ceiling diaphragm to the block walls, and the extent of the vertical starter bar reinforcing,

11 Limitations

a) This report is based on an inspection of the structure with a focus on the damage sustained from the 22 February 2011 Canterbury Earthquake and aftershocks only. Some non-structural damage is mentioned but this is not intended to be a comprehensive list of non-structural items.

b) 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 the time.

c) This report is prepared for the CCC to assist with assessing remedial works required for council buildings and facilities. It is not intended for any other party or purpose.

12 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 (2012), Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes, Structural Engineering Society of New Zealand, 18 September 2012.

[6] DBH (2012), Guidance for engineers assessing the seismic performance of non-residential and multi-unit residential buildings in greater Christchurch, Department of Building and Housing, June 2012.

Appendix 1 - Photographs

Elmwood Park Tool Shed		
No.	Item description	Photo
General		
1.	**Front view of the Tool Shed**	
2.	**Decorative blocks in front wall**	
3.	**Summerhill stone mid-height**	

4.	**Ceiling diaphragm**	
5.	**Used area of tool shed**	
6.	**Lintels spanning over doors**	

7.	**Hairline cracks around decorative blocks**	
8.	**Slab on ground**	

Appendix 2 – CERA DEE Spreadsheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Elmwood Park Tool Shed	Reviewer:	Alistair Boyce
Unit / No: / Street		CPEng No:	209860
Building Address:	25 Heaton St	Company:	Opus International Consultants
Legal Description:		Company project number:	QUCC1.52
		Company phone number:	03 363 5400
GPS south (Degrees / Min / Sec):	43 / 30 / 42.09	Date of submission:	7/02/2013
GPS east (Degrees / Min / Sec):	172 / 36 / 36.33	Inspection Date:	21-Jun-12
		Revision:	Final
Building Unique Identifier (CCC):	PRK 0590 BLDG 003 EQ2	Is there a full report with this summary?	yes

Site

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

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	
Ground floor split?	no		Ground floor elevation above ground (m):	
Storeys below ground	0			
Foundation type:	strip footings		if Foundation type is other, describe:	
Building height (m):	2.00		height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	36			
Age of Building (years):	50		Date of design:	1935-1965
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	other (specify)		Brief strengthening description:	
Use (upper floors):				
Use notes (if required):	park tool shed			
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber framed	rafter type, purlin type and cladding	
Floors:			
Beams:	none	overall depth x width (mm x mm)	
Columns:			
Walls:	partially filled concrete masonry	thickness (mm)	

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	other (note)			Unreinforced, ungrouted CMU
Ductility assumed, μ:	1.00		describe system	
Period along:	0.20	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	other (note)			Unreinforced, ungrouted CMU
Ductility assumed, μ:	1.00		describe system	
Period across:	0.20	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

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

Non-structural elements

Stairs:			
Wall cladding:			
Roof Cladding:	Metal	describe	profiled sheet
Glazing:			
Ceilings:	strapped or direct fixed		FC sheet
Services(list):			

Available documentation

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

Damage

Site:
(refer DEE Table 4-2)

Site performance:	no site disturbance	Describe damage:	
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:			
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:	0%		
	Describe (summary):			
Diaphragms	Damage?:		Describe:	
CSWs:	Damage?:		Describe:	
Pounding:	Damage?:		Describe:	
Non-structural:	Damage?:		Describe:	

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

Recommendations

	Level of repair/strengthening required:	none	Describe:	
	Building Consent required:	no	Describe:	
	Interim occupancy recommendations:	full occupancy	Describe:	
Along	Assessed %NBS before e'quakes:	54%	##### %NBS from IEP below	If IEP not used, please detail assessment methodology: Quantitative
	Assessed %NBS after e'quakes:	54%		
Across	Assessed %NBS before e'quakes:	54%	##### %NBS from IEP below	
	Assessed %NBS after e'quakes:	54%		

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

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