OPUS

Christchurch City Council

Denton Park Shed
PRK 0770 BLDG 012 EQ2

Detailed Engineering Evaluation

Quantitative Assessment Report

Christchurch City Council

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PRK 0770 BLDG 012 EQ2

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Summary

Denton Park Shed
PRK 0770 BLDG 012 EQ2

Detailed Engineering Evaluation
Quantitative Report - Summary
Final

Background
This is a summary of the quantitative report for the Denton Park Shed building, and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011, visual inspections on 8th June & 11th September 2012, measured-up sketch drawings and calculations.

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

Critical Structural Weaknesses
No critical structural weaknesses have been identified for this building.

Indicative Building Strength
Based on the information available, and from undertaking a quantitative assessment, the building's capacity has been assessed as 38% of the new building standard (NBS).

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
It is recommended that strengthening of the building is undertaken to increase the overall building capacity to at least 67% NBS.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council to undertake a detailed seismic assessment of the Denton Park Shed, located at 422 Main South Rd, Hornby, 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
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)

Improvement of Structural Performance	
Legal Requirement	NZSEE Recommendation
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
	Not recommended. Acceptable only in exceptional circumstances
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

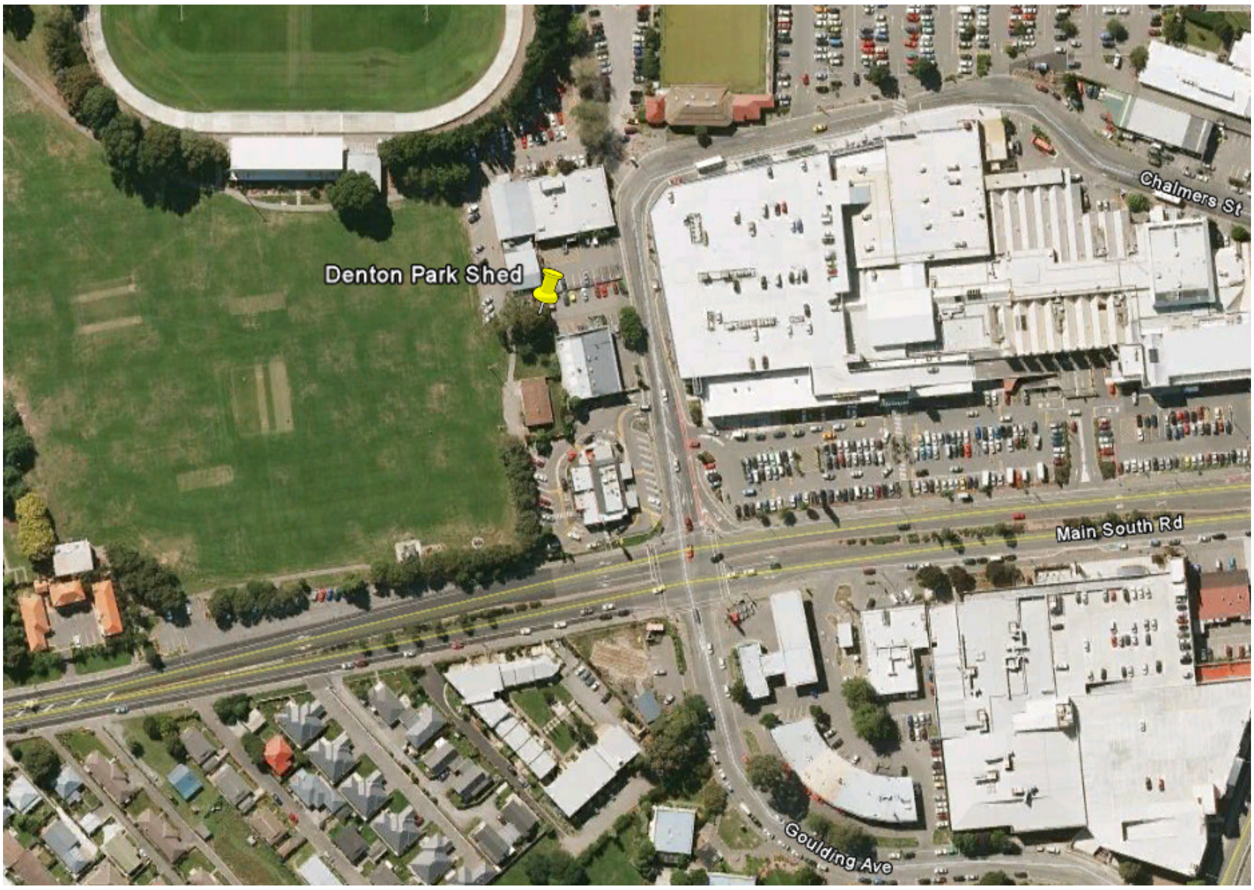

Figure 2 - Location of Denton Park Shed (courtesy Google Earth)

The Denton Park Rugby Shed is a single storey partially reinforced concrete masonry building with a lightweight low pitched corrugated iron roof. The floor is a slab on grade.

The 6m long by 4.5m wide building is situated on relatively flat ground near the edge of Denton Park.

The walls are 2m high running bond, 20 series concrete block masonry. There are high level sections of decorative blocks on all four walls.

4.2 Survey

Visual inspections were carried out on the 8th June 2012 and the 11th September 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.

Our cover meter survey indicated a horizontal bar in the bond beam, vertical starter bars at 600 centres (min 400mm into block walls) extending from the footings, a central vertical bar in the walls, and vertical bars at all corner locations.

4.3 Seismic Load Resisting System

The roof is corrugated iron, supported by four timber trusses and timber purlins. There is no ceiling diaphragm. The bond beam is continuous on all four walls except at the door. Our analysis assumes the roof distributes its own seismic weight in-plane to the masonry walls.

The walls resist the buildings out-of-plane seismic load by cantilevering off the base (fixity from the starter bars along the base of the walls) and distributing the remaining seismic load by the bond beam to the intermediate vertical bars or return walls.

Due to the non-intrusive nature of our survey the extent of grouting in the walls is unknown but is assumed wherever bars are present.

4.4 Original Documentation

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

5 Structural Damage

The building structure does not appear to have suffered any damage as a result of the recent earthquake events. No cracks in the footings were observed. However, intrusive investigations and level surveys have not been undertaken.

6 General Observations

Overall the building has performed well under seismic conditions. The building has sustained no apparent damage and continues to be fully operational. Due to the non-intrusive nature of the original survey, some details could not be ascertained, such as the connection of the walls to the supporting slab.

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 –

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.

No CSW's have been identified for 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} = 1.25

7.3 Quantitative Assessment Methodology

The method of assessment was to determine the building's seismic load using the New Zealand standard NZS1170.5 [1]. The seismic load was then distributed to all seismic resisting elements based on tributary areas, and those elements were assessed for their seismic capacity. The ratio of capacity to load determines the %NBS for each element.

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:

- 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.

7.5 Assessment

A summary of the structural performance of the building is shown in the following table. 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.

Table 2: Summary of Seismic Performance – Original Building, μ = 1.25

Structural Element/System	Failure Mode, or description of limiting criteria based on displacement capacity of critical element.	% NBS based on calculated capacity
Walls along (front and back masonry walls)	Out-of-plane bending	38%
Walls across (side masonry walls)	Out-of-plane bending	38%
Bond Beam	Out-of-plane bending	100%

The calculated seismic capacity of the building has been assessed to be 38%NBS.

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.

8 Summary of Geotechnical Appraisal

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

9 Conclusions

The building has a calculated seismic capacity of 38%NBS and is therefore not considered an earthquake prone building.

10 Recommendations

It is recommended that strengthening of the building is undertaken to increase the overall building capacity to at least 67% NBS.

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 (2011), Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes, Structural Engineering Society of New Zealand, 21 December 2011.

[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

Denton Park Shed		
No.	Item description	Photo
1.	North-eastern view of building	
2.	Northern view of building	
3.	Western view of building	

4.	South-western view of building	
5.	Timber top plate continuous all sides on block walls	
6.	Timber purlins with timber trussed roof	
7.	Looking back to door from inside. Timber top plate continuous over door (no block work lintel/bond beam present)	

Appendix 2 – CERA DEE Spreadsheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name: Denton Park Shed
Unit No: Street
Building Address: 442 Main South Rd
Legal Description:

	Degrees	Min	Sec
GPS south:	43	32	33.98
GPS east:	172	31	18.25

Building Unique Identifier (CCC): PRK 0770 BLDG 012 EQ2

Reviewer: Jan Stanway
CPEng No: 222291
Company: Opus International Consultants
Company project number: QUCC1.55
Company phone number: 03 363 5400
Date of submission: 27-Feb-13
Inspection Date:
Revision: Final
Is there a full report with this summary? yes

Site

Site slope: flat
Soil type:
Site Class (to NZS1170.5): D
Proximity to waterway (m, if <100m):
Proximity to clifftop (m, if < 100m):
Proximity to cliff base (m,if <100m):

Max retaining height (m):
Soil Profile (if available):
If Ground improvement on site, describe:
Approx site elevation (m):

Building

No. of storeys above ground: 1 (single storey = 1)
Ground floor split? no
Storeys below ground 0
Foundation type: strip footings
Building height (m): 2.00
Floor footprint area (approx): 26
Age of Building (years): 50

Ground floor elevation (Absolute) (m):
Ground floor elevation above ground (m):
if Foundation type is other, describe:
height from ground to level of uppermost seismic mass (for IEP only) (m):
Date of design: 1935-1965

Strengthening present? no
If so, when (year)?
And what load level (%g)?
Brief strengthening description:

Use (ground floor): public
Use (upper floors):
Use notes (if required):
Importance level (to NZS1170.5): IL2

Gravity Structure

Gravity System: load bearing walls
Roof: concrete — slab thickness (mm)
Floors:
Beams: none — overall depth x width (mm x mm)
Columns:
Walls: partially filled concrete masonry — thickness (mm)

Lateral load resisting structure

Lateral system along: partially filled CMU
Ductility assumed, μ: 1.25
Period along: 0.40 ##### enter height above at H31
Total deflection (ULS) (mm): 1
maximum interstorey deflection (ULS) (mm): 1

Note: Define along and across in detailed report!

note total length of wall at ground (m):
estimate or calculation? estimated
estimate or calculation? estimated
estimate or calculation? estimated

Lateral system across: partially filled CMU
Ductility assumed, μ: 1.25
Period across: 0.40 ##### enter height above at H31
Total deflection (ULS) (mm): 1
maximum interstorey deflection (ULS) (mm): 1

note total length of wall at ground (m):
estimate or calculation? estimated
estimate or calculation? estimated
estimate or calculation? estimated

Separations:

north (mm):
east (mm):
south (mm):
west (mm):

leave blank if not relevant

Non-structural elements

Stairs:
Wall cladding:
Roof Cladding: Metal — describe: corrugated iron
Glazing:
Ceilings: none
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 (summary):
Describe how damage ratio arrived at:

Across — Damage ratio: 0%
Describe (summary):

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

Diaphragms — Damage?: — Describe:
CSWs: — Damage?: — Describe:
Pounding: — Damage?: — Describe:
Non-structural: — Damage?: — Describe:

Recommendations

Level of repair/strengthening required: significant structural — Describe: masonry wall strengthening
Building Consent required: — Describe:
Interim occupancy recommendations: full occupancy — Describe: Not to be used as a workplace.

Along
Assessed %NBS before e'quakes: 38% ##### %NBS from IEP below
Assessed %NBS after e'quakes: 38%

If IEP not used, please detail assessment methodology: Quantitative

Across
Assessed %NBS before e'quakes: 38% ##### %NBS from IEP below
Assessed %NBS after e'quakes: 38%

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