Edmonds Factory Garden Marquee
PRK 1338 BLDG 003 EQ2
Detailed Engineering Evaluation
Quantitative Report

Christchurch City Council

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Detailed Engineering Evaluation Quantitative Report

Opus International Consultants Ltd
Hamilton Office
Princes Street
Private Bag 3057, Waikato Mail Centre,
Hamilton 3240
New Zealand

Telephone:	+64 7 838 9344
Facsimile:	+64 7 838 9324

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Detailed Engineering Evaluation
Quantitative Report - SUMMARY
Final

359 Ferry Road, Christchurch

Background

This is a summary of the quantitative report for the marquee structure in the Edmonds Factory Garden. The summary is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group, visual inspections and measurements taken on 5 June 2012, and calculations.

Indicative Structure Strength

Based on the information available, and from undertaking a quantitative assessment, the structure's original capacity has been assessed to be greater than 100% NBS, both along and across the structure, and is therefore a low earthquake risk.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the marquee located in the Edmonds Factory Garden at 359 Ferry Road, Christchurch. This report was commissioned following the M6.3 Christchurch earthquake on 22 February 2011.

The purpose of the assessment is to determine if the structure 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 procedure detailed in the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011.

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. It uses 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 owner's 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 requires 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 has 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.

Any building with a capacity of less than 34% of new building standard (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67% as required by 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).

Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council) 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 CCC as being 67% of the strength of an equivalent new building. 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 (EPB)

This section defines a building as earthquake prone 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.

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:

- 36% increase in the basic seismic design load for Christchurch (Z factor increased from 0.22 to 0.3);
- 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). It is noted that the current seismic risk in Christchurch results in a 6% risk of exceedance 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 Earthquake Prone Buildings (EPB). Such a building would be issued with a Section 124 notice by the Territorial Authority, or CERA acting on their behalf, once they are

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

made aware of our assessment. Based on information received from CERA to date, this notice is likely to prohibit occupancy of the building (or parts of it) 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/Christchurch City Council 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.

4 Building Description

4.1 General

The marquee is a single storey steel-framed structure with open walls and a light plastic roof. The building sits on a concrete slab. We have no information on the foundation and have assumed that it is a concrete pad foundation.

The building is situated on a flat section and is approximately 12m long in the north-south direction and 4.5m wide in the east-west direction. The apex of the roof is approximately 3.7m above the ground and the building has a wall height of approximately 2.2m.

We have no information on when the structure was constructed.

4.2 Gravity Load Resisting System

The roof is steel-framed with light plastic sheeting supported on steel columns. The columns are circular hollow sections with an external diameter of 101.6mm. The columns appear to be cast directly into the concrete base slab

4.3 Seismic Load Resisting System

Lateral resistance for the structure in the transverse direction is provided through the moment resisting steel frames, in the longitudinal direction, lateral resistance is provided by the columns cantilevering off the concrete slab.

5 Survey

The structure currently has no placard (none issued as part of this inspection).

No copies of the design calculations or structural drawings have been obtained for this structure however, we have now measured the structure accurately and made calculations based on these figures.

Non-intrusive inspections have been used to confirm the structural systems, and to identify details which required particular attention.

6 General Observations

The structure has performed well under seismic conditions.

7 Detailed Seismic Assessment

7.1 Seismic Coefficient Parameters

The seismic design parameters based on current design requirements from NZS1170.5:2004 and the NZBC clause B1 for this structure 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 R_u = 0.5 from Table 3.5, NZS 1170.5:2004, for an Importance Level 1 structure with a 50 year design life.
- Ductility factor μ_{max} = 2 for the steel structure.

7.2 Detailed Seismic Assessment Results

A summary of the structural performance of the structure is shown in the following table. Note that the values given represent the worst performing elements in the structure, as these effectively define the structure's capacity. Other elements within the structure may have significantly greater capacity when compared with the governing element.

Table 2: Summary of Seismic Performance

Structural Element/System	Failure mode and description of limiting criteria	% NBS based on calculated capacity
Transverse direction, portal frames	Moment capacity of the frame	>100%
Longitudinal direction, cantilevered columns	Moment capacity of the columns	>100%

7.3 Discussion of Results

The structure has a calculated capacity of greater than 100% NBS with the capacity being limited by the moment capacity of the columns. This is above the threshold limit for structures classified as 'Earthquake Prone' which is one third (33%) of the seismic performance specified in the current loading standard for new structures. The structure is therefore classed as having a low earthquake risk in accordance with the NZSEE guidelines.

7.4 Limitations and Assumptions in Results

Our analysis and assessment is based on an assessment of the structure in its undamaged state.

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; and
- without an intrusive investigation the capacity of the foundation cannot be determined but, due to the small loads being imparted on them, it is assumed that their capacity is greater than 100% NBS.

8 Conclusions

(a) The structure has a seismic capacity of greater than 100% NBS and therefore has a low earthquake risk.

(b) The seismic capacity is governed by the moment capacity of the steel columns.

9 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.

(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 structures and facilities. It is not intended for any other party or purpose.

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

Appendix A – Photographs

Photo 1: The end wall of the structure and a typical frame.

Photo 2: Typical roof beam columns joint.

Photo 3: The apex joint.

Photo 4: View of purlin connection.

Appendix B – Building Plan

Calculation Sheet

Project/Task/File No: Marquee Edmond's Gardens

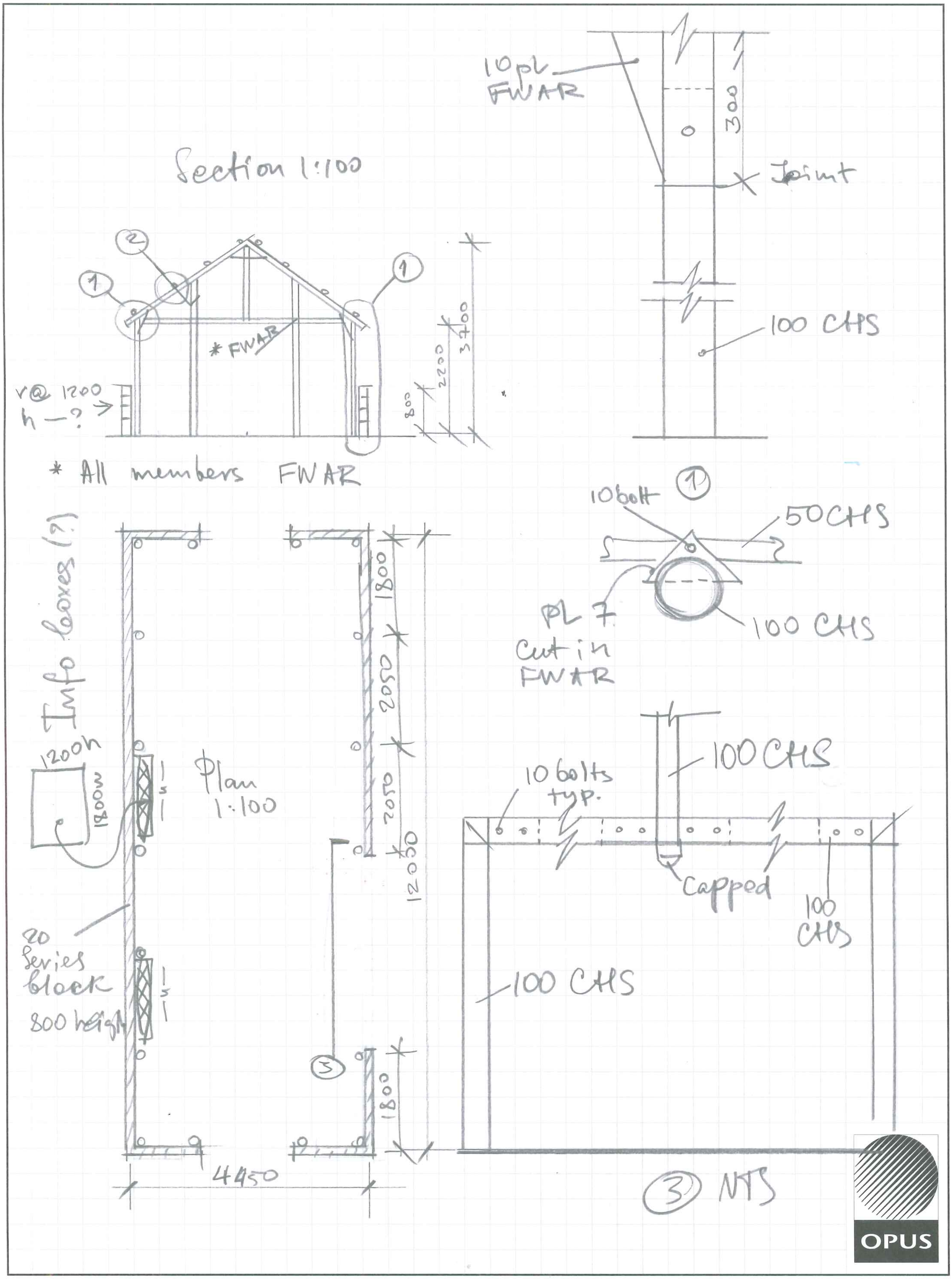
Project/Description:

Sheet No of

Office:

Computed: / /

Checked: / /



Appendix C – CERA DEEP Data Sheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name: Edmonds Factory Garden Marquee
Building Address: Unit: No: 359 Street: Ferry Rd
Legal Description:
GPS south: Degrees: Min: Sec:
GPS east:
Building Unique Identifier (CCC): PRK 133 BLDG 003 EQ2

Reviewer: Oliver Lang
CPEng No: 1013082
Company: Opus International Consultants
Company project number: 6QUCC1.09
Company phone number: 03 363 5400
Date of submission: 15-Oct-12
Inspection Date: 5-Jun-12
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): 5.00

Building

No. of storeys above ground: 1 (single storey = 1)
Ground floor split? no
Storeys below ground 0
Foundation type: other (describe)
Building height (m): 3.70
Floor footprint area (approx): 53
Age of Building (years):

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

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): IL1

Gravity Structure

Gravity System: frame system
Roof: steel framed — rafter type, purlin type and cladding: Steel tube, corrugated plastic
Floors: concrete flat slab — slab thickness (mm):
Beams: steel non-composite — beam and connector type:
Columns: structural steel — typical dimensions (mm x mm): 101.6x1.6 CHS
Walls: non-load bearing — 0

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along: other (note) — describe system: Steel columns cantilevering off foundations
Ductility assumed, μ: 2.00
Period along: 0.00 — estimate or calculation?
Total deflection (ULS) (mm): — estimate or calculation?
maximum interstorey deflection (ULS) (mm): — estimate or calculation?

Lateral system across: welded and bolted steel moment frame — note typical bay length (m):
Ductility assumed, μ: 2.00
Period across: 0.00 — estimate or calculation?
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: exposed structure — describe
Roof Cladding: Other (specify) — describe: corrugated plastic
Glazing: aluminium frames
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: — 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: green

Along — Damage ratio: 0% — Describe how damage ratio arrived at:
Describe (summary):

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

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

Diaphragms — Damage?: no — Describe:
CSWs: — Damage?: no — Describe:
Pounding: — Damage?: no — Describe:
Non-structural: — Damage?: no — Describe:

Recommendations

Level of repair/strengthening required: none — Describe:
Building Consent required: no — Describe:
Interim occupancy recommendations: full occupancy — Describe:

Along — Assessed %NBS before: 100% ##### %NBS from IEP below — If IEP not used, please detail assessment methodology:
Assessed %NBS after: 100%

Across — Assessed %NBS before: 100% ##### %NBS from IEP below
Assessed %NBS after: 100%

IEP

Use of this method is not mandatory - more detailed analysis may give a different answer, which would take precedence. Do not fill in fields if not using IEP.

Period of design of building (from above): 0 — h_n from above: m
Seismic Zone, if designed between 1965 and 1992: — not required for this age of building
not required for this age of building: b) Intermediate

	along	across
Period (from above):	0	0
(%NBS)nom from Fig 3.3:	0.0%	0.0%

Note:1 for specifically design public buildings, to the code of the day: pre-1965 = 1.25; 1965-1976, Zone A =1.33; 1965-1976, Zone B = 1.2; all else 1.0 — 1.00
Note 2: for RC buildings designed between 1976-1984, use 1.2 — 1.0
Note 3: for buildngs designed prior to 1935 use 0.8, except in Wellington (1.0) — 1.0

	along	across
Final $(\%NBS)_{nom}$:	**0%**	**0%**

2.2 Near Fault Scaling Factor
Near Fault scaling factor, from NZS1170.5, cl 3.1.6: 1.00

	along	across
Near Fault scaling factor (1/N(T,D), **Factor A**:	1	1

2.3 Hazard Scaling Factor
Hazard factor Z for site from AS1170.5, Table 3.3: 0.00
Z_{1992}, from NZS4203:1992: 0.8
Hazard scaling factor, **Factor B:** #DIV/0!

2.4 Return Period Scaling Factor
Building Importance level (from above): 1
Return Period Scaling factor from Table 3.1, **Factor C**: 1.00

2.5 Ductility Scaling Factor

	along	across
Assessed ductility (less than max in Table 3.2)	1.25	1.25
Ductility scaling factor: =1 from 1976 onwards; or =kμ, if pre-1976, fromTable 3.3:	1.00	1.00
Ductiity Scaling Factor, **Factor D**:	1.00	1.00

2.6 Structural Performance Scaling Factor:

	along	across
Sp:	0.925	0.925
Structural Performance Scaling Factor **Factor E**:	1.081081081	1.081081081

2.7 Baseline %NBS, $(NBS\%)_b = (\%NBS)_{nom} \times A \times B \times C \times D \times E$ — **$\%NBS_b$:** **#DIV/0!** | **#DIV/0!**

Global Critical Structural Weaknesses: (refer to NZSEE IEP Table 3.4)

3.1. Plan Irregularity, factor A: significant — 0.7
3.2. Vertical irregularity, Factor B: insignificant — 1
3.3. Short columns, Factor C: insignificant — 1
3.4. Pounding potential
Pounding effect D1, from Table to right: 1.0
Height Difference effect D2, from Table to right: 1.0
Therefore, Factor D: 1
3.5. Site Characteristics significant — 0.7

Table for selection of D1	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Alignment of floors within 20% of H	**0.7**	**0.8**	**1**
Alignment of floors not within 20% of H	**0.4**	**0.7**	**0.8**

Table for Selection of D2	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Height difference > 4 storeys	0.4	0.7	1
Height difference 2 to 4 storeys	0.7	0.9	1
Height difference < 2 storeys	1	1	1

3.6. Other factors, Factor F

	Along	Across
For ≤ 3 storeys, max value =2.5, otherwise max valule =1.5, no minimum	0.0	0.0

Rationale for choice of F factor, if not 1: Piled foundations will limit any effects of liquefaction induced settlement

Detail Critical Structural Weaknesses: (refer to DEE Procedure section 6)
List any: Plan irregularity — Refer also section 6.3.1 of DEE for discussion of F factor modification for other critical structural weaknesses

	along	across
3.7. Overall Performance Achievement ratio (PAR)	**0.00**	**0.00**
4.3 PAR x (%NBS)b: PAR x Baselline %NBS:	**#DIV/0!**	**#DIV/0!**
4.4 Percentage New Building Standard (%NBS), (before)		**#DIV/0!**

OPUS