Fendalton Library Cycle Shed

BU 0450-002 EQ2

Detailed Engineering Evaluation

Quantitative Report

Christchurch City Council

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Detailed Engineering Evaluation Quantitative Report

Prepared by

Michael Cullum
Graduate Structural Engineer

Reviewed by

Oliver Lang
Senior Structural Engineer
CPEng 1013082

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

Fendalton, Christchurch

Background

This is a summary of the quantitative report for the Fendalton Library Cycle Shed. 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.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Fendalton Library Cycle Shed, located behind the library in the car park. 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:

- 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
- 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
- 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
- there is a risk that other property could collapse or otherwise cause injury or death; or
- 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 cycle shed is a single storey timber-framed structure with open walls and a light flat metal roof. The building sits on circular concrete pile foundations.

The building is situated on a flat section and is approximately 5m long in the longitudinal direction and 2m wide in the transverse direction. The roof is approximately 2m above the ground.

We have no information on when the structure was constructed.

4.2 Gravity Load Resisting System

The roof is timber framed with light metal sheeting supported on timber beams and posts.

4.3 Seismic Load Resisting System

Lateral support for the structure in the transverse directions is provided by the moment resisting timber frame. In the longitudinal direction the earthquake loads are resisted by the columns cantilevering off the foundations. The columns are 100mm x 100mm and each beam consists of two 150mm x 25mm sections of timber nailed together.

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 measured the structure and undertaken our assessment using that survey information.

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} = 2.00 for the timber framed structure.

7.2 Detailed Seismic Assessment Results

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

Table 2: Summary of Seismic Performance

Structural Element/System	Failure mode and description of limiting criteria	% NBS based on calculated capacity
Frame in the longitudinal direction i.e. along the structure	Moment capacity of the columns Moment capacity of the foundation connection	>100% >100%
Frame in the transverse direction i.e. across the structure	Moment capacity of the columns Moment capacity of the beams Moment capacity of the beam/column connection Moment capacity of the foundation connection	>100% >100% >100% >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 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 piles 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 accordance with the NZSEE guidelines.

(b) The seismic capacity is governed by the moment capacity of the foundation connections.

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: View of the front of the structure.

Photo 2: View of the beam column joint.

Photo 3: View of the foundation joint.

Appendix B – Building Plan

Appendix C – CERA DEEP Data Sheet

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