Botanic Gardens Petrol Store

PRK 1566 BLDG 042 EQ2

Detailed Engineering Evaluation

Quantitative Report

Christchurch City Council

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Botanic Gardens Petrol Store

Detailed Engineering Evaluation Quantitative Report

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Botanic Gardens Petrol Store Structure
PRK 1566 BLDG 042 EQ2

Detailed Engineering Evaluation
Quantitative Report - SUMMARY
Final

Botanic Gardens, Christchurch

Background

This is a summary of the quantitative report for the Botanic Gardens Petrol Store structure, and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011, visual inspections on 20 March 2012 and calculations.

Key Damage Observed

No seismic damage was identified.

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 original capacity has been assessed to be in the order of 100% NBS.

Recommendations

a) The lid should be mechanically fixed to the walls to prevent it falling off if subjected to high vertical accelerations.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Petrol Store building, located in the Christchurch Botanic Gardens following the M6.3 Christchurch earthquake on 22 February 2011.

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 quantitative procedures 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 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.

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 (CCC)) 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

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.

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	Improvement of Structural Performance: Legal Requirement	Improvement of Structural Performance: 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). 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 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.

3.1.2 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.

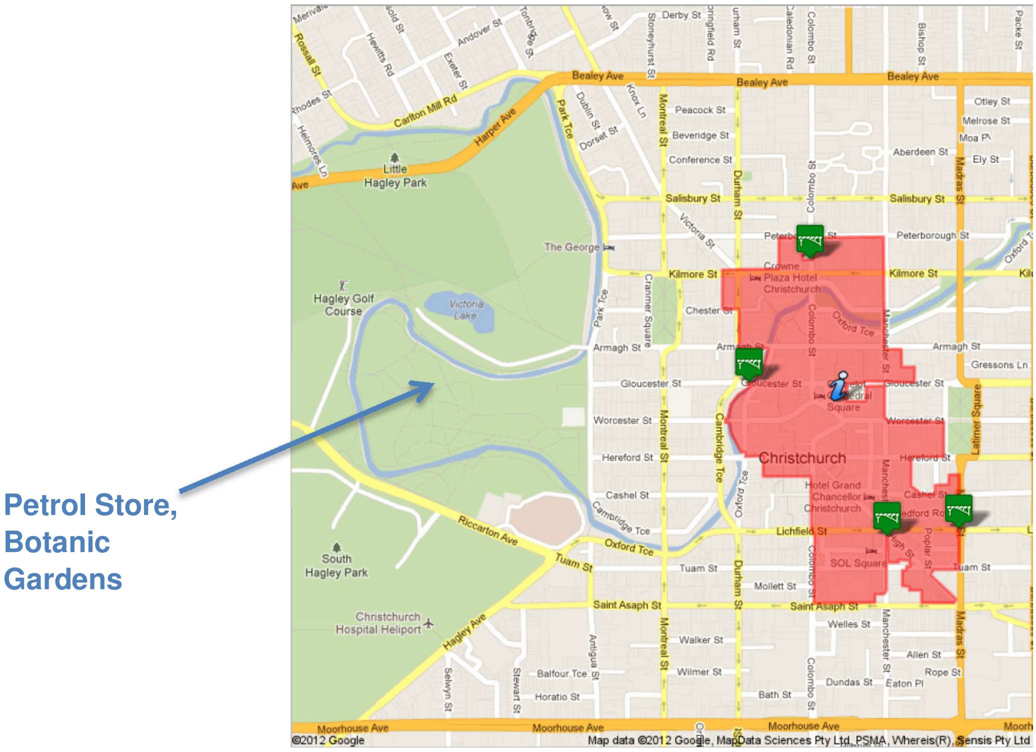
3.1.3 Our Ethical Obligation

- 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 Background Information

4.1 Building Description

The Petrol Store is a small, vertical pipe structure (1.95 metres high, 2.0 metres diameter) with a concrete lid and base slab without foundations. The lid has shear lugs to prevent it from sliding off. It is effectively a portable building that will not readily transmit ground shaking into the structure. The primary seismic risks are thus rocking, the lid falling off and/or overturning.



CBD Red Zone Cordon Map as at 18 May 2012

4.2 Survey

No rapid assessment of this structure had been undertaken past 22 February 2011.

5 Structural Damage

The structure shows only minor cracking and spalling, however it is deemed this is a result of age and usage. No intrusive investigation was undertaken.

6 General Observations

The structure appears to have generally performed well during the earthquake. It is expected no strengthening or repair will be required.

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 21 December 2011.

7.1 Quantitative Assessment Methodology

The quantitative assessment assumed the following:

(i) The governing ultimate limit state would be stability, not strength (in accordance with AS/NZS 1170.0-2002 Section 7.2.1), due to the structural nature of the Petrol Store (i.e. a low-height, freestanding vertical concrete pipe), it would have excess strength capacity, and a reduced seismic response due to sliding or rocking.

(ii) The response of the Petrol Store to ground acceleration would be rocking, due to there being no physical attachment of the footing to the ground.

7.2 Limitations and Assumptions in Results

Our analysis and assessment is based on an assessment of the building 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.
- Approximations made in the assessment of the capacity of each element, especially when considering the post-yield behaviour.

7.3 Quantitative Assessment Results

Based on an ultimate limit state stability analysis, the structure achieves a seismic capacity greater than 100%NBS.

8 Geotechnical Appraisal

Due to the simple nature of this structure a geotechnical investigation was not deemed necessary. Subsidence resulting from liquefaction could occur in a future seismic event but this is unlikely to result in collapse due to the type of structure.

9 Remedial Options

There are no cracks or separation of the lid bedding mortar that would indicate that there has been lifting of the lid during an earthquake event. However, due to known vertical seismic accelerations that have occurred, there is the possibility that these vertical accelerations combined with a rocking lateral response, could result in the lid coming off. To prevent this we recommend that the lid be mechanically fixed to the walls by steel cleats and masonry anchors.

Otherwise we find the structure requires no repairs or strengthening.

10 Conclusions

a) The seismic performance of the Petrol Store structure is governed by stability and achieves a seismic capacity greater than 100%NBS for the ultimate limit state.

b) The lid should be mechanically fixed to the walls to prevent it falling off if subjected to high vertical accelerations.

11 Recommendations

a) The lid should be mechanically fixed to the walls to prevent it falling off if subjected to high vertical accelerations.

12 Limitations

a) This report is based on an inspection of the structure of the buildings and focuses on the structural damage resulting from the 22 February 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 this time.

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

13 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 1 – Photographs

Petrol Store – Christchurch Botanic Gardens		
No.	**Item description**	**Photo**
1.	Overall photo of Petrol Store	
2.	Lid of Petrol Store and exhaust pipe	
3.	Shear lugs on lid	

4.	Defects as a result of usage and age	

Appendix 2 – CERA DEE Data Sheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Botanic Gardens Petrol Store	Reviewer:	Alistair Boyce
	No: 3 Street: Rolleston Ave	CPEng No:	209860
Building Address:	3 Rolleston Ave	Company:	Opus International Consultants
Legal Description:		Company project number:	6-QUCC1.04
		Company phone number:	03 363 5400
GPS south:	Degrees 43, Min 31, Sec 47.55	Date of submission:	16-Oct-12
GPS east:	Degrees 172, Min 37, Sec 22.09	Inspection Date:	20/03/2012
		Revision:	Final
Building Unique Identifier (CCC):	PRK 1566-BLDG-042 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):	41	If Ground improvement on site, describe:	
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	5.00

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:	other (describe)	if Foundation type is other, describe:	slab sitting on ground
Building height (m):	1.95	height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	3		
Age of Building (years):	10	Date of design:	
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):	petrol container store		
Importance level (to NZS1170.5):	IL1		

Gravity Structure

Gravity System:	load bearing walls		
Roof:	concrete	slab thickness (mm)	60 min
Floors:			
Beams:			
Columns:			
Walls:	load bearing concrete	#N/A	75

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	other (note)		describe system	vertical freestanding concrete pipe
Ductility assumed, μ:	1.25			
Period along:	0.10	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):	1		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	other (note)		describe system	vertical freestanding concrete pipe
Ductility assumed, μ:	1.25			
Period across:	0.10	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):	1		estimate or calculation?	estimated
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:	
Glazing:	
Ceilings:	
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:		notes (if applicable):	
Differential settlement:		notes (if applicable):	
Liquefaction:		notes (if applicable):	
Lateral Spread:		notes (if applicable):	
Differential lateral spread:		notes (if applicable):	
Ground cracks:		notes (if applicable):	
Damage to area:		notes (if applicable):	

Building:

	Current Placard Status:			
Along	Damage ratio:		Describe how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:	#DIV/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:		Describe:	
	Interim occupancy recommendations:	full occupancy	Describe:	
Along	Assessed %NBS before e'quakes:	##### %NBS from IEP below	If IEP not used, please detail assessment methodology:	quantitative
	Assessed %NBS after e'quakes:	100%		
Across	Assessed %NBS before e'quakes:	##### %NBS from IEP below		
	Assessed %NBS after e'quakes:	100%		

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