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Project:

Bottle Lake Forest Chemical Shed

Qualitative Engineering Evaluation

Reference: 228587

Prepared for: Christchurch City Council

Revision: 2

Date: 22 November 2012

Functional Location ID: PRK 0158 BLDG 015 EQ2

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Executive Summary

This is a summary of the Qualitative and Quantitative Report for the Bottle Lake Forest Chemical Shed building structure and is based on the Detailed Engineering Evaluation Procedure document issued by the Structural Advisory Group on 19 July 2011, visual inspections, available structural documentation and summary calculations as appropriate.

Building Details	**Name**	Bottle Lake Forest Chemical Shed	**BuildLoc ID:**	PRK 0158 BLDG 015 EQ2	
Building Address	70 Waitikiri Road, Christchurch				
Foot Print (approx. m²)	7	**Storeys above ground**	1	**Storeys below ground**	0
Approximate Year Built	1990s	**Building Age Years**	Approx. 10	**Number of res. units**	0
Building Current Use	Chemical storage shed				
Type of Construction	Modified precast concrete water tank with a door opening				

Qualitative L4 Report Results Summary		
Building Occupied	Y	Currently used as chemical storage shed
Suitable for Continued Occupancy	Y	Suitable for continued use
Critical Structural Weaknesses	N	No critical structural weaknesses were found
Building %NBS From Analysis	100%	From specific analysis
Key Damage Summary	Y	Refer to summary of building damage section 4.1 report body.

Qualitative L4 Report Recommendations		
Levels Survey Required	N	Low importance level, apparent minimal damage to structure
Geotechnical Survey Required	N	Uncategorised, Technical Category 2 by extrapolation
Multiple Structure Site	Y	Bottle Lake Forest Park
Proceed Directly To L5 Quantitative DEE	N	A quantitative DEE is not required for this structure.

Approval			
Author Signature		Approver Signature	
Name	Christopher Bong	Name	Luis Castillo
Title	Structural Engineer	Title	Senior Structural Engineer

1. Introduction

1.1 General

On 12 March 2012, Aurecon engineers visited the Bottle Lake Forest Chemical Shed to carry out a qualitative and quantitative building damage assessment on behalf of Christchurch City Council. Detailed visual inspections were carried out to assess the damage caused by the earthquakes on 4 September 2010, 22 February 2011, 13 June 2011, 23 December 2011 and their subsequent aftershocks.

The scope of work included:

- Assessment of the nature and extent of the building damage.
- Visual assessment of the building strength particularly with respect to safety of occupants if the building is currently occupied.

This report outlines the results of our qualitative assessment of damage to the Bottle Lake Forest Chemical Shed and is based on the Detailed Engineering Evaluation Procedure document issued by the Structural Advisory Group on 19 July 2011, visual inspections, available structural documentation and summary calculations as appropriate.

2. Description of the Building

2.1 Building Age and Configuration

The Bottle Lake Forest Chemical Shed is a small modified precast concrete water tank with a door opening built circa 1990. The roof consists of a concrete lid with a gentle flat slope.

The approximate floor area of the chemical shed is 7 square metres and is classified as a building with an importance level of 1 (building with a floor area less than 30 m^2) according to NZS 1170 Part 0: 2002.

2.2 Building Vertical and Horizontal Structural Systems

The vertical and horizontal loads of the structure are resisted by the 150 mm thick precast reinforced concrete walls. The walls support the concrete lid roof and work primarily in bearing and compression. The wind and seismic actions on the other hand are resisted by the reinforced concrete in shear.

2.3 Building Foundation System and Soil Conditions

The chemical shed appears to be founded on good ground with no specific foundations; typical for a structure of this nature.

CERA land zone maps indicate that Bottle Lake Forest Park currently sits on “Yet To be Classified Rural & Unmapped Land”, however the land to the immediate south has classed as Technical Category 2 Land. By extrapolation, the land is deemed unlikely to be subject to liquefaction or settlement in to future earthquakes. The site investigation has shown no obvious ground disturbance or movement have been noted in the immediate vicinity of the shed.

2.4 Available Structural Documentation and Inspection Priorities

The building drawings were unavailable for review. And as such; this report is based solely on the interior and exterior visual inspection which was undertaken on 12 March 2012.

3. Structural Investigation

3.1 Summary of Building Damage

Small diagonal cracks were observed around the door opening. These cracks are a result of stresses concentrations around the door opening. They appear to be fresh and may be a result of seismic actions.

The smooth edges around the door opening suggests that the door opening was not cut post construction and therefore it is assumed that trimming bars are present to control these cracks.

3.2 Record of Intrusive Investigation

The chemical shed is a small modified precast concrete water tank with a door opening. The building appears to have minimal damage when a visual inspection was carried out in the interior and exterior façade of the building.

The lack of fixings to the chemical shed has allowed for most of the façade of the structure to be investigated.

3.3 Damage Discussion

It appears that the building has suffered little to no damage as a result of the seismic activity. This is not surprising as buildings of this nature are inherently stiff and will therefore exhibit very low levels of displacement damage. Furthermore, the walls form a hollow cylindrical shape which is a very efficient in resisting torsional forces in a seismic event.

3.4 Reference Building Type

As previously stated, the chemical shed is a small modified precast concrete water tank with a door opening. The roof system consists of a concrete lid.

4. Building Review Summary

The observed displacement damage for this building was found to be minor thus implying a commensurate degree of damage to the corresponding structural elements.

5. Building Strength (Refer to Appendix D for background information)

The primary failure mode this this structure is overturning which has been checked by analysis. The analysis has shown that the chemical shed has stability in excess of 100% NBS.

6. Conclusions and Recommendations

Visual inspection and conversations with the park rangers have indicated that there is little noticeable damage to the building from to the recent seismic events. Analysis has confirmed that the shed has sufficient stability to resist overturning from code level seismic events accordingly it is considered acceptable to continue to use the structure without further assessment or strengthening.

7. Explanatory Statement

The inspections of the building discussed in this report have been undertaken to assess structural earthquake damage. No analysis has been undertaken to assess the strength of the building or to determine whether or not it complies with the relevant building codes, except to the extent that Aurecon expressly indicates otherwise in the report. Aurecon has not made any assessment of structural stability or building safety in connection with future aftershocks or earthquakes – which have the potential to damage the building and to jeopardise the safety of those either inside or adjacent to the building, except to the extent that Aurecon expressly indicates otherwise in the report.

This report is necessarily limited by the restricted ability to carry out inspections due to potential structural instabilities/safety considerations, and the time available to carry out such inspections. The report does not address defects that are not reasonably discoverable on visual inspection, including defects in inaccessible places and latent defects. Where site inspections were made, they were restricted to external inspections and, where practicable, limited internal visual inspections.

To carry out the structural review, existing building drawings were obtained from the Christchurch City Council records. We have assumed that the building has been constructed in accordance with the drawings.

While this report may assist the client in assessing whether the building should be strengthened, that decision is the sole responsibility of the client.

This review has been prepared by Aurecon at the request of its client and is exclusively for the client's use. It is not possible to make a proper assessment of this review without a clear understanding of the terms of engagement under which it has been prepared, including the scope of the instructions and directions given to and the assumptions made by Aurecon. The report will not address issues which would need to be considered for another party if that party's particular circumstances, requirements and experience were known and, further, may make assumptions about matters of which a third party is not aware. No responsibility or liability to any third party is accepted for any loss or damage whatsoever arising out of the use of or reliance on this report by any third party.

Without limiting any of the above, Aurecon's liability, whether under the law of contract, tort, statute, equity or otherwise, is limited as set out in the terms of the engagement with the client.

Appendices

Appendix A

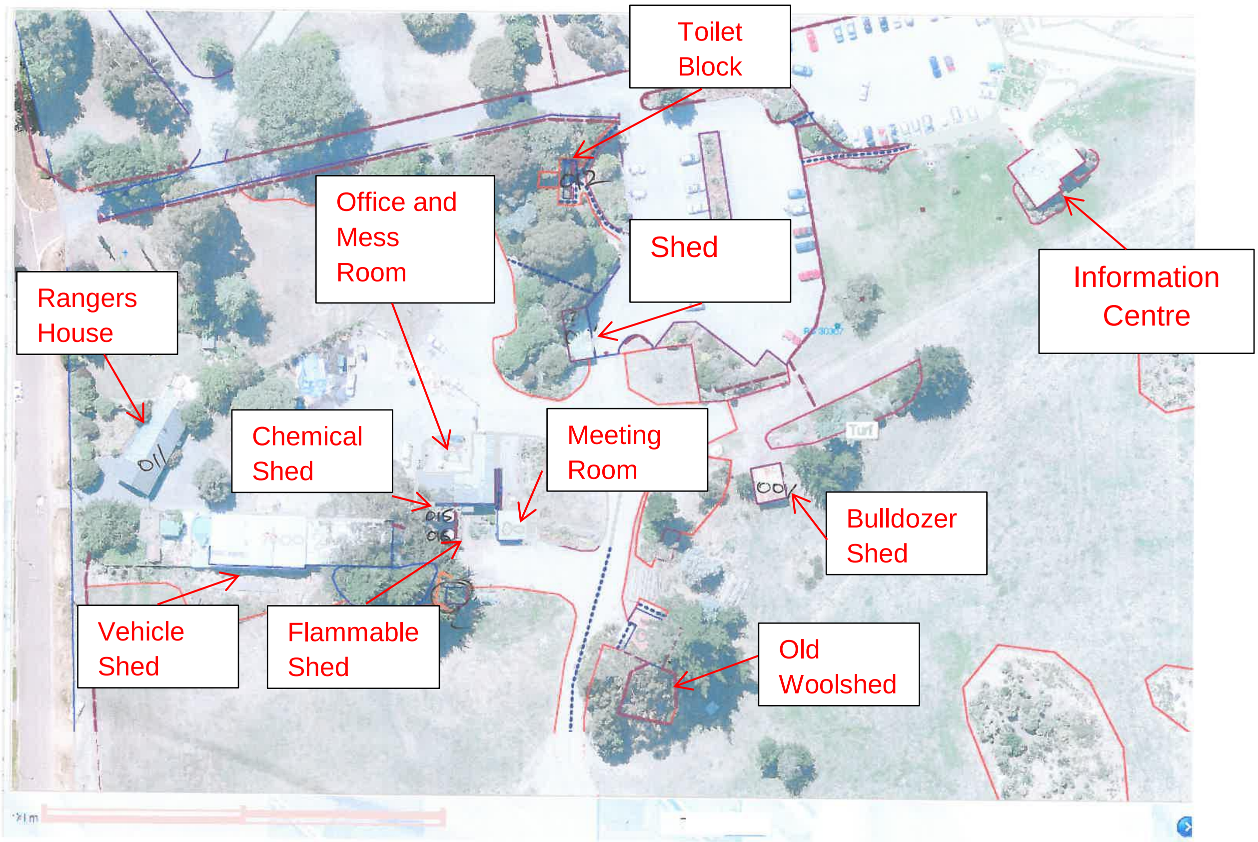
Photos

Site photographs (12 March 2012)

Front Elevation and Rear Elevations of the Chemical Shed

Fresh crack around the door opening

Appendix B
Site Layout



Appendix C
References

Reference Documents and Materials

- AS/NZS 1170 Parts 0,1 and 5 and commentaries;
- New Zealand Society for Earthquake Engineering (NZSEE) 2006 Study Group Recommendations "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" – June 2006
- Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-Residential Buildings in Canterbury. Part 2 Evaluation Procedure. Draft prepared by Engineering Advisory Group, Revision 5, 19 July 2011.

Appendix D
Strength Assessment Explanation

New building standard (NBS)

New building standard (NBS) is the term used with reference to the earthquake standard that would apply to a new building of similar type and use if the building was designed to meet the latest design Codes of Practice. If the strength of a building is less than this level, then its strength is expressed as a percentage of NBS.

Earthquake prone buildings

A building can be considered to be earthquake prone if its strength is less than one third of the strength to which an equivalent new building would be designed, that is, less than 33%NBS (as defined by the New Zealand Build Act). If the building strength exceeds 33%NBS but is less than 67%NBS the building is considered at risk.

Christchurch City Council Earthquake Prone Building Policy 2010

The Christchurch City Council (CCC) already had in place an Earthquake Prone Building Policy (EPB Policy) requiring all earthquake-prone buildings to be strengthened within a timeframe varying from 15 to 30 years. The level to which the buildings were required to be strengthened was 33%NBS.

As a result of the 4 September 2010 Canterbury earthquake the CCC raised the level that a building was required to be strengthened to from 33% to 67% NBS but qualified this as a target level and noted that the actual strengthening level for each building will be determined in conjunction with the owners on a building-by-building basis. Factors that will be taken into account by the Council in determining the strengthening level include the cost of strengthening, the use to which the building is put, the level of danger posed by the building, and the extent of damage and repair involved.

Irrespective of strengthening level, the threshold level that triggers a requirement to strengthen is 33%NBS.

As part of any building consent application fire and disabled access provisions will need to be assessed.

Christchurch Seismicity

The level of seismicity within the current New Zealand loading code (AS/NZS 1170) is related to the seismic zone factor. The zone factor varies depending on the location of the building within NZ. Prior to the 22nd February 2011 earthquake the zone factor for Christchurch was 0.22. Following the earthquake the seismic zone factor (level of seismicity) in the Christchurch and surrounding areas has been increased to 0.3. This is a 36% increase.

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 new building standard load requirements have been determined in accordance with the current earthquake loading standard (NZS 1170.5:2004 Structural design actions - Earthquake actions - New Zealand).

The likely capacity of this building has been derived in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) guidelines 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes' (AISPBE), 2006. These guidelines provide an Initial Evaluation Procedure that assesses a buildings capacity based on a comparison of loading codes from when the building was designed and currently. It is a quick high-level procedure that can be used when undertaking a Qualitative analysis of a building. The guidelines also provide guidance on calculating a modified Ultimate Limit State capacity of the building which is much more accurate and can be used when undertaking a Quantitative analysis.

The New Zealand Society for Earthquake Engineering has proposed a way for classifying earthquake risk for existing buildings in terms of %NBS and this is shown in Figure 3.1 below.

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement	Unacceptable	Unacceptable

Figure 3.1: NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE Guidelines

Table 3.1 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 3.1: %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

Appendix E

Detailed Engineering Evaluation Summary Data

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Chemical Shed			Reviewer:	Simon Manning
	Unit	No:	Street	CPEng No:	132053
Building Address:	Bottle Lake Forest	70	Waitikiri Drive	Company:	Aurecon
Legal Description:				Company project number:	228587
				Company phone number	03 375 0761
	Degrees	Min	Sec		
GPS south:	43	28	8.18	Date of submission:	April
GPS east:	172	40	51.43	Inspection Date:	March
				Revision:	0
Building Unique Identifier (CCC):	PRK 0158 BLDG 015 EQ2			Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:	mixed	Soil Profile (if available):	
Site Class (to NZS1170.5):	D		
Proximity to waterway (m, if <100m):		If Ground improvement on site, describe:	
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	3.30

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	3.45
Ground floor split?	no		Ground floor elevation above ground (m)	0.15
Storeys below ground				
Foundation type	other (describe)		if Foundation type is other, describe	Precast Concrete
Building height (m):	2.60		height from ground to level of uppermost seismic mass (for IEP only) (m):	2.5
Floor footprint area (approx):	7			
Age of Building (years):	10		Date of design:	1992-2004
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):	storage building			
Importance level (to NZS1170.5):	IL1			

Gravity Structure

Gravity System:	load bearing walls		
Roof:	concrete	slab thickness (mm)	
Floors:	other (note)	describe sytem	Precast Concrete
Beams:	none	overall depth x width (mm x mm)	
Columns:	load bearing walls	typical dimensions (mm x mm)	
Walls:	load bearing concrete	#N/A	

Lateral load resisting structure

Lateral system along:	concrete shear wall	**Note: Define along and across in detailed report!**	note total length of wall at ground (m):	
Ductility assumed, μ:			wall thickness (m):	
Period along:		##### enter height above at H31	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	estimated
Lateral system across:	concrete shear wall		note total length of wall at ground (m):	
Ductility assumed, μ:			wall thickness (m):	
Period across:		##### enter height above at H31	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	estimated

Separations:

north (mm):		leave blank if not relevant

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

Non-structural elements

Stairs:	
Wall cladding:	
Roof Cladding:	
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:		Describe damage:	minor - none
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: — Describe how damage ratio arrived at:
Describe (summary):

Across — Damage ratio:
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: — 0% %NBS from IEP below — If IEP not used, please detail assessment methodology:
Assessed %NBS after:

Across — Assessed %NBS before: — 0% %NBS from IEP below
Assessed %NBS after:

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): 1992-2004

h_n from above: 2.5m

Seismic Zone, if designed between 1965 and 1992: B

not required for this age of building

Design Soil type from NZS4203:1992, cl 4.6.2.2:

	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:	0.30
Z_{1992}, from NZS4203:1992	0.8
Hazard scaling factor, **Factor B:**	2.666666667

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)	2.00	2.00
Ductility scaling factor: =1 from 1976 onwards; or $=k_\mu$, if pre-1976, fromTable 3.3:	2.00	2.00
Ductiity Scaling Factor, **Factor D**:	1.00	1.00

2.6 Structural Performance Scaling Factor:

	along	across
Sp:	1.000	1.000
Structural Performance Scaling Factor **Factor E**:	1	1

2.7 Baseline %NBS, $(NBS\%)_b = (\%NBS)_{nom}$ x A x B x C x D x E

	along	across
$\%NBS_b$:	**0%**	**0%**

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

3.1. Plan Irregularity, factor A:	insignificant	1
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

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

3.5. Site Characteristics	significant	0.7

3.6. Other factors, Factor F

	Along	Across
For ≤ 3 storeys, max value =2.5, otherwise max valule =1.5, no minimum	1.0	1.0
Rationale for choice of F factor, if not 1		

Detail Critical Structural Weaknesses: (refer to DEE Procedure section 6)

List any: Refer also section 6.3.1 of DEE for discussion of F factor modification for other critical structural weaknesses

3.7. Overall Performance Achievement ratio (PAR)		**0.70**	**0.70**
4.3 PAR x (%NBS)b:	PAR x Baselline %NBS:	**0%**	**0%**
4.4 Percentage New Building Standard (%NBS), (before)			**0%**

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