CLIENTS | PEOPLE | PERFORMANCE

Elm Grove Block A

BU 0782 -001 EQ2

Detailed Engineering Evaluation

Quantitative Report

Version FINAL

8-14 Elm Grove
Linwood
Christchurch

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Elm Grove Block A
BU 0782 -001 EQ2

Detailed Engineering Evaluation
Quantitative Report
Version FINAL

8-14 Elm Grove
Linwood
Christchurch

Christchurch City Council

Prepared By
Kevan O Brien

Reviewed By
Derek Chinn

Date
07 December 2012

Contents

Table Index

Figure Index

Appendices

Quantitative Report Summary

Elm Grove Block A

BU 0782 -001 EQ2

Detailed Engineering Evaluation

Quantitative Report - SUMMARY

Version FINAL

8-14 Elm Grove

Linwood

Christchurch

Background

This is a summary of the Quantitative report for the above building structure, and is based in general on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011, NZS 3604:2001 Timber-Framed buildings, a visual inspection carried out on the 29th of October 2012 and a review of the original drawings held by Christchurch City Council.

Brief Description

Elm Grove block A is located at 8-14 Elm Grove, Linwood. The building was constructed in 1953. The building has a floor area of approximately 133m^2.

The site is predominantly flat with insignificant variations in ground levels throughout.

The building is a single storey timber framed structure with masonry fire walls. The roof is timber framed with timber sarking under a lightweight metal cladding. Internal and external walls are timber framed with plasterboard linings. A 190mm thick unreinforced concrete masonry wall separates each of the individual units. This fire wall is clad with 50mm battens at 600mm centres with plasterboard linings. Externally the building is clad with timber weatherboard cladding. The floor consists of timber flooring supported on timber bearers on 200mm x 200mm concrete piles.

The dimensions of the building are approximately 22m long, 6m wide and 4.5m in height.

Key Damage Observed

- Minor cracking to plasterboard wall linings
- Cracking to perimeter strip footing
- Cracking to external concrete paving adjacent to the building

Critical Structural Weaknesses

No critical structural weaknesses were noted when evaluating the building.

Indicative Building Strength (from bracing calculations and CSW assessment)

Following a detailed assessment the building has been assessed as achieving 35% New Building Standard (NBS) for loading along the building and 100% NBS for loading across the building. Under the New Zealand Society for Earthquake Engineering (NZSEE) guidelines the building is considered to be an Earthquake Risk as it achieves less than 67% NBS.

Recommendations

The building has been assessed as an Earthquake Risk building and as such it is recommended that strengthening works are carried out to strengthen the building to a minimum of 67% NBS with NZSEE recommendations. However, the observed damage to the structure does not affect the lateral load resisting system. In addition the building does not pose an immediate risk to users and occupants as no collapse hazards have been identified, therefore it is recommended that general occupancy of the building continue in accordance with Christchurch City Councils policy regarding Earthquake Prone buildings.

1. Background

GHD Limited has been engaged by Christchurch City council to undertake a detailed engineering evaluation of the Elm Grove block A building located at Elm Grove in Linwood.

As the building is of lightweight timber frame construction, and initially built in 1988, the Initial Evaluation Procedure (IEP) developed by the New Zealand Society for Earthquake Engineering (NZSEE) will generally provide a conservative result. Therefore, this report is a Quantitative Assessment of the building structure, and is based in general on NZS 3604:2011 Timber-Framed buildings, wall lining bracing capacities from NZS 3604:1981 and the New Zealand Society for Earthquake Engineering (NZSEE) guidelines.

A quantitative assessment involves a full site measure of the building and a review of the original consent drawings which is used to determine the buildings bracing capacity in accordance with manufacturers' guidelines, where available. The capacities of the wall linings from NZS 3604:1981 are used to determine the bracing capacity of the walls. The demand for the building is determined in accordance with NZS 3604:2011, from this the percentage of new building standard (%NBS) is assessed.

The detailed analysis consisted of a bracing calculation of the structure and therefore no further analysis or calculations were carried out.

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 carry out a full structural survey before the building is re-occupied.

We understand that CERA will 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). It is anticipated that CERA will adopt the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This document sets out a methodology for both qualitative and quantitative assessments.

The qualitative assessment is a desk-top and site inspection assessment. It is based on a thorough visual inspection of the building coupled with a review of available documentation such as drawings and specifications. The quantitative assessment involves analytical calculation of the buildings strength and may require non-destructive or destructive material testing, geotechnical testing and intrusive investigation.

It is anticipated that factors determining the extent of evaluation and strengthening level required will include:

- The importance level and occupancy of the building
- The placard status and amount of damage
- The age and structural type of the building
- Consideration of any critical structural weaknesses
- The extent of any earthquake damage

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 any 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)) be satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'. Regarding seismic capacity 'as near as reasonably practicable' has previously been interpreted by CCC as achieving a minimum of 67% NBS however where practical achieving 100% NBS is desirable. The New Zealand Society for Earthquake Engineering (NZSEE) recommend a minimum of 67% NBS.

2.2.1 Section 121 – Dangerous Buildings

The definition of dangerous building in the Act was extended by the Canterbury Earthquake (Building Act) Order 2010, and it now 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 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

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 ground shaking 33% of the shaking 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 of the 4th September 2010.

The 2010 amendment includes the following:

- A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
- A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
- A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
- 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.

We anticipate that any building with a capacity of less than 33% NBS (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67% NBS of new building standard as recommended by the Policy.

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.

After the February Earthquake, on 19 May 2011, Compliance Document B1: Structure was amended to include increased seismic design requirements for Canterbury as follows:

- Hazard Factor increased from 0.22 to 0.3 (36% increase in the basic seismic design load)
- Serviceability Return Period Factor increased from 0.25 to 0.33 (80% increase in the serviceability design loads when combined with the Hazard Factor increase)

The increase in the above factors has resulted in a reduction in the level of compliance of an existing building relative to a new building despite the capacity of the existing building not changing.

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 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 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 1 NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE

Table 1 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.

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

Table 1 %NBS compared to relative risk of failure

4. Building Description

4.1 General

Elm Grove block A is located at 8-14 Elm Grove, Linwood. The building was constructed in 1953. The building has a floor area of approximately 133m^2.

The site is predominantly flat with insignificant variations in ground levels throughout.

The building is a single storey timber framed structure with masonry fire walls. The roof is timber framed with timber sarking under a lightweight metal cladding. Internal and external walls are timber framed with plasterboard linings. A 190mm thick unreinforced concrete masonry wall separates each of the individual units. This fire wall is clad with 50mm battens at 600mm centres with plasterboard linings. Externally the building is clad with timber weatherboard cladding. The floor consists of timber flooring supported on timber bearers on 200mm x 200mm concrete piles.

The dimensions of the building are approximately 22m long, 6m wide and 4.4m in height. Refer Figure 2 below for the ground floor plan.

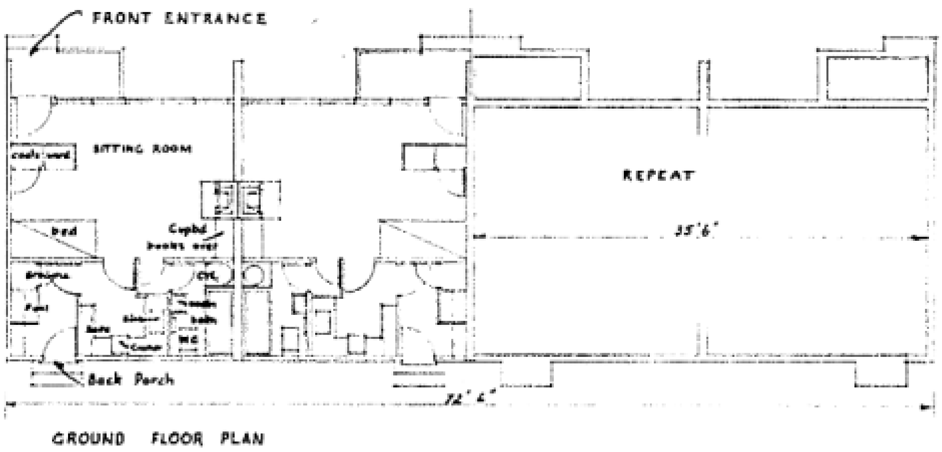


Figure 2 Block A Floor Plan

4.2 Gravity Load Resisting System

Self-weight and applied roof loads are carried by timber rafters which span the building in the transverse direction. Load from the trusses is transferred to the supporting timber framed external walls and these bear on concrete strip foundations which allow the total building load above including the masonry cladding to be supported by the ground beneath. The floor is a timber floor supported by timber bearers that span between the external concrete perimeter strip foundation and supported intermittently by concrete piles.

4.3 Lateral Load Resisting System

Seismic loads in both lateral directions are resisted primarily by the plasterboard lined timber framed walls performing as in-plane bracing panels. In addition to this timber framed wall bracing, the unreinforced fire wall masonry will provide resistance to seismic loads in the transverse direction.

The heavy masonry boundary fire wall makes the presence of a ceiling diaphragm very important to prop the out-of-plane seismic load of the wall. Though no diagonal ceiling bracing could be observed, a plasterboard ceiling was present and is likely to provide some nominal diaphragm capability.

5. Inspection

A visual inspection of the building was undertaken on the 29th of October 2012. Both the interior and exterior of the building were inspected. No placard was evident during the inspection, however based on the inspection carried out it would be expected to have a green placard. The main structural components of the building were all able to be viewed due to the relatively exposed nature of the structure.

The inspection consisted of a review of the available drawings and observing the building to determine the structural systems and likely behaviour of the building during an earthquake. The site was assessed for damage, including examination of the ground conditions, checking for damage in areas where damage would be expected for the type of structure and noting general damage observed throughout the building in both structural and non-structural elements.

The %NBS score determined for this building has been based on detailed calculations as described in Section 7 of this report and based on the information obtained from visual observation of the building and available drawings. The damage that has occurred has not reduced the overall lateral load resistance of the building. Therefore for the purposes of the assessment of the building and the determination of the %NBS score, the effects of this damage on the performance of the building has not reduced the overall strength of the building.

5.1 Damage Assessment

5.1.1 Surrounding Buildings

Minor damage to surrounding buildings was observed during our inspection of the site. This was mainly in the form of cracking to plasterboard linings, and cracking to external paved areas.

5.1.2 Residual Displacements and General Observations

Minor cracking was noted to plasterboard linings in several locations throughout the building however this is not deemed to affect the load carrying capacity of the structural systems.

Minor cracking to the perimeter strip footing was observed however it is possible this cracking was a pre-existing shrinkage crack that has opened up during the recent seismic activity.

No damage was evident to the roof structure.

5.1.3 Floor level survey

A floor level survey was carried out as per the Christchurch City Councils request. This showed insignificant amounts of settlement throughout the building

5.1.4 Ground Damage

There was evidence of minor movement and settlement of concrete slab on grade floors in neighbouring buildings, there was no evidence of ground movement or settlement within the building. Discussions on site indicate that no liquefaction occurred as a result of the recent seismic activity.

6. Geotechnical Consideration

6.1 Site Description

The site is situated in the suburb of Linwood, east of the Christchurch CBD. It is relatively flat at approximately 4m above mean sea level. It is approximately 190m south of the Avon River, and 7km west of the coast (Pegasus Bay).

6.2 Published Information on Ground Conditions

6.2.1 Published Geology

Brown & Weeber, 1992[1] describes the site geology as:

- Dominantly alluvial sand and silt overbank deposits, being alluvial soils of the Yaldhurst Member, sub-group of the Springston Formation, Holocene in age;
- Underlying sediments (younger than 6500 years) are indicated to be peat;
- The Riccarton gravels are located approximately 24m bgl; and
- Groundwater is likely within 1m of ground level.

6.2.2 Environment Canterbury Logs

Information from Environment Canterbury (ECan) indicates that four boreholes with lithographic logs are located within 200m of the site. Ecan boreholes with appropriate logs are summarised in Table 2.

These indicate the area is underlain by sand and silt lenses to 26m bgl, underlain by gravels to 45m bgl. Varying amounts of clay and peat are also indicated to be present.

Groundwater was recorded between 9.14m and 10.9m bgl in the borehole logs.

Table 2 ECan Borehole Summary

Bore Name	Log Depth	Groundwater	From Site	Log Summary
M35/15216	45m	Not recorded	120m NW	0.0 to 1.0m Sand 1.0 to 1.9m Sandy Silt
M35/16962	1.5m	Not recorded	140m NE	0.0 to 1.0m Sand 1.0 to 1.5m Sandy Silt
M35/2247	129.5m	9.14m	190m NW	0.0 to 19.5m Unknown 19.5 to 26.8m Sand and Clay 26.8 to 45.4m Gravel
M35/1922	128m	10.9m	190m NW	0.0 to 4.5m Surface soil and Sand

[1] Brown, L. J. & Weeber, J.H. (1992): *Geology of the Christchurch Urban Area*. Institute of Geological and Nuclear Sciences 1:25,000 Geological Map 1. IGNS Limited: Lower Hutt.

Bore Name	Log Depth	Groundwater	From Site	Log Summary
				4.5 to 21.3m Sand
				21.3 to 26.6m Clay and Peat
				26.6 to 45.0m Gravel

It should be noted that the logs have been written by the well driller and not a geotechnical professional or to a standard. In addition strength data is not recorded.

6.2.3 EQC Geotechnical Investigations

The Earthquake Commission has undertaken geotechnical testing in the area of the site. Information pertaining to this investigation is included in the Tonkin & Taylor Report for Linwood[2]. One investigation points were undertaken within 200m of the site, as summarised below in Table 3.

Table 3 EQC Geotechnical Investigation Summary Table

Bore Name	Orientation from Site	Depth (m bgl)	Log Summary[3]
CPT LWD 17	70m S	0 – 1.2	Pre-drilled
		1.2 – 5.0	Clays, stiff
		5.0 – 8.2	Sands, medium dense
		8.2 – 8.7	Sand mixture, loose
		8.7 - 23	Sands, medium dense to dense
			(WT assumed at 2.0m bgl)

Initial observations of the CPT results indicate the soils are fine medium grained, and are loose to medium dense.

6.2.4 CERA Land Zoning

Canterbury Earthquake Recovery Authority (CERA) has indicated the site is situated within the Green Zone, indicating that repair and rebuild may take place.

Land in the CERA green zone has been divided into three technical categories. These categories describe how the land is expected to perform in future earthquakes.

The site is indicated as being within the TC2 (yellow) zone[4]. This means that minor to moderate land damage from liquefaction is possible is future significant earthquakes.

[2] Tonkin & Taylor Ltd., 2011: Christchurch Earthquake Recovery, *Geotechnical Factual Report, Linwood.*

[3] Log Summary for CPT's interpreted from Soil Behavior Type Robertson *et al*. 2010.

[4] CERA Landcheck website, http://cera.govt.nz/my-property

6.2.5 Post Earthquake Land Observations

Aerial photography[5] taken following the significant earthquakes of the Canterbury earthquake sequence show no signs of liquefaction outside the building footprint or adjacent to the site, aerial photography taken 22 Feburary 2011 earthquake is shown in Figure 3.

Figure 3 Post February 2011 Earthquake Aerial Photography

The Canterbury Geotechnical database shows there are cracks less than 10mm within 100m of the site[6].

6.2.6 Summary of Ground Conditions

From the information presented above, the ground conditions underlying the site are anticipated to comprise sand and silt layers with occasional peat lenses to 26m bgl, underlain by the Riccarton gravels.

Groundwater is considered to vary between 2.0m and 10.9m bgl.

[5] Aerial Photography Supplied by Koordinates sourced from http://koordinates.com/layer/3185-christchurch-post-earthquake-aerial-photos-24-feb-2011/

[6] Canterbury Geotechnical Database (2012) "Observed Ground Crack Locations", Map Layer CGD0400 - 23 July 2012, retrieved [02/11/2012] from https://canterburygeotechnicaldatabase.projectorbit.com/

6.3 Seismicity

6.3.1 Nearby Faults

There are many faults in the Canterbury region, however only those considered most likely to have an adverse effect on the site are detailed below.

Table 4 Summary of Known Active Faults[7,8]

Known Active Fault	Distance from Site	Direction from Site	Max Likely Magnitude	Avg Recurrence Interval
Alpine Fault	130km	NW	~8.3	~300 years
Greendale Fault (2010)	23km	W	7.1	~15,000 years
Hope Fault	105km	N	7.2~7.5	120~200 years
Kelly Fault	110km	NW	7.2	~150 years
Porters Pass Fault	60km	NW	7.0	~1100 years
Port Hills Fault (2011)	6km	S	6.3	Not Estimated

The recent earthquake sequence since 4 September 2010 has identified the presence of a previously unmapped active fault system underneath the Canterbury Plains; this includes the Greendale Fault and Port Hills Fault listed in Table 4 above. Research and published information on this system is in development and the average recurrence interval is yet to be established for the Port Hills Fault.

6.3.2 Ground Shaking Hazard

New Zealand Standard NZS 1170.5:2004 quantifies the Seismic Hazard factor for Christchurch as 0.30, being in a moderate to high earthquake zone. This value has been provisionally upgraded recently (from 0.22) to reflect the seismicity hazard observed in the earthquakes since 4 September 2010.

The recent seismic activity has produced earthquakes of Magnitude 6.3 with significant peak ground accelerations (PGA) across large parts of the city.

Conditional PGA's from the CGD[9] indicate the PGA to be 0.21g during the 4 September 2010 earthquake, 0.46g on 22 February 2011, and 0.26g on 13 June 2011.

[7] Stirling, M.W, McVerry, G.H, and Berryman K.R. (2002): "A New Seismic Hazard Model for New Zealand", *Bulletin of the Seismological Society of America*, Vol. 92 No. 5, June 2002, pp. 1878-1903.

[8] GNS Active Faults Database, http://maps.gns.cri.nz/website/af/viewer

[9] Canterbury Geotechnical Database (2012): "Conditional PGA for Liquefaction Assessment", Map Layer CGD5110 - 27 Sept 2012, retrieved 31/10/2012 from https://canterburygeotechnicaldatabase.projectorbit.com/

6.4 Slope Failure and/or Rockfall Potential

The topography surrounding the site suggests that rockfall is not a potential hazard. Given its proximity to the Avon River (within 200m), and evidence of no liquefaction from the recent earthquakes, the site is considered to have a low susceptibility to lateral spreading. In addition, any retaining structures or embankments nearby should be further investigated to determine the site-specific local slope instability potential.

6.5 Liquefaction Potential

The site is considered to have a low to moderate susceptibility to liquefaction, due to the following reasons:

- No observations of liquefaction in post-earthquake aerial photography; and,
- The site has been classified as TC2; and,
- The presence of saturated sands and silt mixtures beneath the site.

6.6 Summary & Recommendations

This assessment is based on a review of the geology and existing ground investigation information, and observations from the Christchurch earthquakes since 4 September 2010.

The site appears to be situated on sand and silt layers with occasional peat lenses underlain by gravels. Associated with this the site also has a low to moderate liquefaction potential, in particular where sands and/or sand mixtures are present.

The site is considered to have a low susceptibility to lateral spreading.

A soil class of **D** (in accordance with NZS 1170.5:2004) should be adopted for the site.

Should a more comprehensive liquefaction and/or ground condition assessment be required, it is recommended that intrusive investigation be conducted.

7. Quantitative Assessment

7.1 Quantitative Assessment Procedure

A full site measure of the building was carried out on the 8th of November 2012. This, along with available drawings, were used to determine the buildings bracing demand in accordance NZS 3604:2011, wall lining bracing capacities from NZS 3604:1981 and the NZSEE guidelines. From the results of the assessment the percentage of new building standard (%NBS) was determined.

7.2 Building demand

The demand on the structure was determined in accordance with Section 5 of NZS 3604:2011. The bracing unit demand per square metre was determined from Table 5.8. In accordance with Table 5.8 of NZS 3604: 2011 for a light roof, light weight cladding, a heavy subfloor cladding and with a roof pitch less than 25°, a bracing demand of 11 BU/m^2 is taken. For Earthquake Zone 2, which covers Christchurch, and site subsoil class D this demand is reduced by a factor of 0.8. Therefore the total demand for the building is;

$$BU_{demand} = (0.8 \text{ x } 11 \ \ BU/m^2 \text{ x } 133m^2)$$

$$= 1172 \text{ BU}$$

7.3 Wall bracing capacity

The building was constructed in 1953 and as such, no bracing capacities for the wall linings were available for the calculations. Therefore the capacities are taken in accordance with Table 11.1 of the in NZSEE guidelines Table 11.1.

Section 11.4 of the NZSEE guidelines states that shear panels can utilise their full bracing capacity for aspect ratios (height-to-width) up to 2:1. For aspect ratios greater than 2:1 and up to 3.5:1 a limiting factor can be applied in accordance with the NEHRP Recommended Provisions (BSSC, 2000) as follows;

$$\text{Aspect ratio factor} = \frac{2\text{x Width}}{\text{Height}}$$

Any sections of wall with an aspect ratio greater than 3.5:1 were not included for the purpose of the bracing calculations.

The bracing capacities along and across the building are as follows:

Along the building

$BU_{Provided}$ = 410 BU's

Across the building

$BU_{Provided}$ = 2386 BU's

7.4 Capacity of Un-reinforced Masonry Walls

7.4.1 In-Plane Capacity of the Unreinforced Walls

The in-plane capacity of the unreinforced concrete masonry wall was determined using the NZSEE guidelines for the Assessment and Improvement of Unreinforced Masonry Buildings for Earthquake Resistance (06/2006). The NZSEE guidelines recommend checks for 4 different in-plane response modes.

- Diagonal tension failure mode
- Bed-sliding failure mode
- Toe crushing failure mode
- Rocking failure mode

An analysis of each wall was carried out using the methods set out in Section 8 – In-Plane Wall Response, of the NZSEE guidelines for the Assessment and Improvement of Unreinforced Masonry Buildings for Earthquake Performance (06/2006).

7.4.2 In-plane Wall Shear Capacity of the Unreinforced Walls

The in-plane nominal shear capacity of a wall, pier or spandrel was taken as the minimum of the nominal capacity in the diagonal tension failure mode, V_{dt}, the rocking failure mode, V_r, the bed-joint sliding failure mode, V_s, and the toe crushing failure mode, V_{tc}.

$$V_n = \min(V_{dt}, V_s, V_r, V_{tc})$$

7.4.3 Out-of-Plane Capacity of the Unreinforced Walls

The % NBS for out-of-plane flexure of the concrete masonry walls was determined using the methods set out in NZSEE guidelines for the Assessment and Improvement of the Structural Performance of Buildings in Earthquakes Section 10.3.

7.4.4 %NBS

The capacities both along and across the building are compared to the demand for each of the elements to determine the critical direction, and therefore determine the overall %NBS for the building

Along the building

$$\%NBS_{along} = 35\%$$

Across the building

$$\%NBS_{across} = 100\%$$

Following a detailed assessment the building has been assessed as achieving 35% New Building Standard (NBS). Under the New Zealand Society for Earthquake Engineering (NZSEE) guidelines the building is considered to be an Earthquake Risk building as it achieves less than 67% NBS.

7.5 Discussion of Results

The results obtained are consistent with a building of this age, the number of bracing elements present within the building and construction type (unreinforced concrete masonry). The building has a strength less than 67%NBS and therefore is deemed to be an Earthquake Risk building. It is recommended that strengthening works are carried out to strengthening the building to a minimum of 67% NBS in accordance with NZSEE recommendations and Christchurch City Councils policy regarding earthquake Prone buildings.

7.6 Occupancy

As the building has been assessed to have a %NBS less than 67%NBS, it is deemed to be an Earthquake Risk building. However, as there are no immediate collapse hazards or critical structural weaknesses present in the building, it is recommended that general occupancy of the building is permitted.

8. Conclusions

The building has been assessed as an Earthquake Risk building and as such it is recommended that strengthening works are carried out to strengthen the building to a minimum of 67% NBS. However, the observed damage to the structure does not affect the lateral load resisting system. In addition the building does not pose an immediate risk to users and occupants as no collapse hazards have been identified, therefore it is recommended that general occupancy of the building continue in accordance with Christchurch City Councils policy regarding Earthquake Prone buildings.

9. Limitations

9.1 General

This report has been prepared subject to the following limitations:

- No intrusive structural investigations have been undertaken.
- No intrusive geotechnical investigations have been undertaken.
- No level or verticality survey has been carried out
- No material testing has been undertaken.
- No calculations, other than the wall bracing calculations, have been carried out on the structure

It is noted that this report has been prepared at the request of Christchurch City Council, and is intended to be used for their purposes only. GHD accepts no responsibility for any other party or person who relies on the information contained in this reportrite a specific limitations section.

9.2 Geotechnical Limitations

This report presents the results of a geotechnical appraisal prepared for the purpose of this commission, and for prepared solely for the use of Christchurch City Council, and their advisors. The data and advice provided herein relate only to the project and structures described herein and must be reviewed by a competent geotechnical engineer before being used for any other purpose. GHD Limited (GHD) accepts no responsibility for other use of the data.

The advice tendered in this report is based on a visual geotechnical appraisal. No subsurface investigations have been conducted. An assessment of the topographical land features have been made based on this information. It is emphasised that Geotechnical conditions may vary substantially across the site from where observations have been made. Subsurface conditions, including groundwater levels can change in a limited distance or time. In evaluation of this report cognisance should be taken of the limitations of this type of investigation.

An understanding of the geotechnical site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experienced based. Hence this report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances, which arise from the issue of the report, which have been modified in any way as outlined above.

Appendix A

Photographs

Photograph 1 Front elevation.

Photograph 2 Rear elevation.

Photograph 3 Side walls with lightweight cladding.

Photograph 4 Roof structure.

Photograph 5 Cracking to external paving.

Photograph 6 Cracking to plasterboard linings.

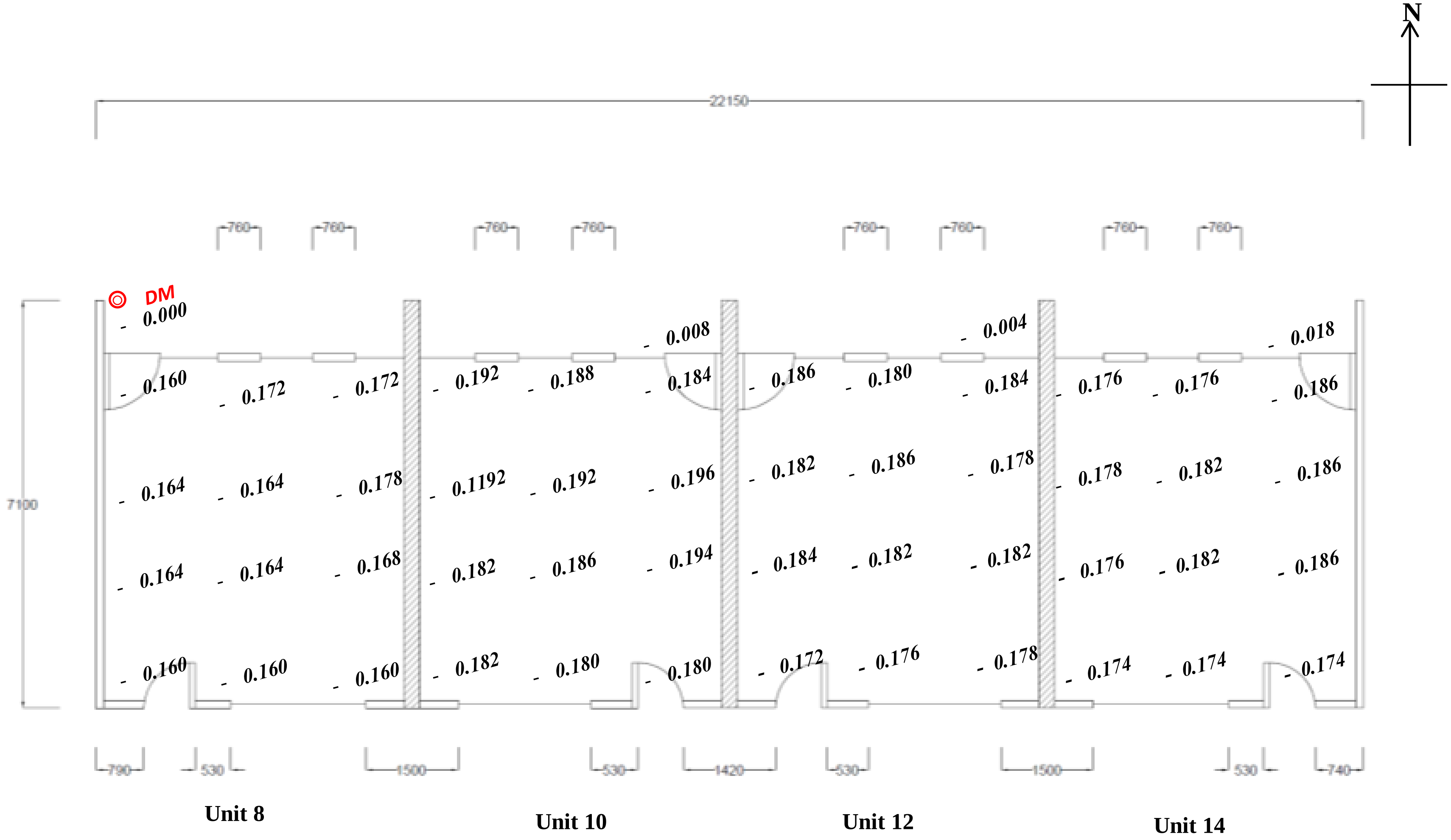
Photograph 7 Timber bearer supported by concrete pile.

Appendix B

Existing Drawings

Appendix C

Level Plan



Floor Level Survey Plan – Block A

51/30902/78/

Detailed Engineering Evaluations

Elm Grove Block A

Appendix D

CERA Building Evaluation Form

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Elm Grove Block A			Reviewer:	Derek Chinn
	Unit	No:	Street	CPEng No:	177243
Building Address:	8 to 14		Elm Grove	Company:	GHD
Legal Description:				Company project number:	513090278
				Company phone number:	03 378 0900
	Degrees	Min	Sec		
GPS south:	43	31	41.00	Date of submission:	27/11/2012
GPS east:	172	39	5.00	Inspection Date:	29/10/2012
				Revision:	0
Building Unique Identifier (CCC):	BU 0782 BLDG 001 EQ2			Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:	silty sand	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):	4.00

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	4.50
Ground floor split?	no		Ground floor elevation above ground (m):	4.50
Storeys below ground	0			
Foundation type:	strip footings		if Foundation type is other, describe:	
Building height (m):	4.40		height from ground to level of uppermost seismic mass (for IEP only) (m):	4.4
Floor footprint area (approx):	97			
Age of Building (years):	59		Date of design:	1935-1965
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	multi-unit residential		Brief strengthening description:	
Use (upper floors):				
Use notes (if required):				
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber framed	rafter type, purlin type and cladding	
Floors:	timber	joist depth and spacing (mm)	
Beams:			
Columns:	load bearing walls	typical dimensions (mm x mm)	
Walls:			

Lateral load resisting structure

Lateral system along:	lightweight timber framed walls	**Note: Define along and across in detailed report!**		
Ductility assumed, μ:	2.00		note typical wall length (m)	
Period along:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	lightweight timber framed walls			
Ductility assumed, μ:	2.00		note typical wall length (m)	
Period across:	0.40	0.00	estimate or calculation?	estimated
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:	plaster system	describe	Plasterboard linings
Roof Cladding:	Metal	describe	
Glazing:			
Ceilings:	fibrous plaster, fixed		
Services(list):			

Available documentation

Architectural	partial	original designer name/date	Christchurch City Council
Structural	partial	original designer name/date	Christchurch City Council
Mechanical		original designer name/date	
Electrical		original designer name/date	
Geotech report		original designer name/date	

Damage

Site:	Site performance:			Describe damage:	
(refer DEE Table 4-2)					
	Settlement:	none observed		notes (if applicable):	
	Differential settlement:	none observed		notes (if applicable):	
	Liquefaction:	none apparent		notes (if applicable):	
	Lateral Spread:	none apparent		notes (if applicable):	
	Differential lateral spread:	none apparent		notes (if applicable):	
	Ground cracks:	none apparent		notes (if applicable):	
	Damage to area:	none apparent		notes (if applicable):	

Building:					
	Current Placard Status:				
Along	Damage ratio:	0%		Describe how damage ratio arrived at:	
	Describe (summary):				
Across	Damage ratio:	0%			
	Describe (summary):				
Diaphragms	Damage?:	no		Describe:	
CSWs:	Damage?:	no		Describe:	
Pounding:	Damage?:	no		Describe:	
Non-structural:	Damage?:	yes		Describe:	Minor cracking in some plasterboard

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

Recommendations

	Level of repair/strengthening required:			Describe:	
	Building Consent required:			Describe:	
	Interim occupancy recommendations:			Describe:	
Along	Assessed %NBS before e'quakes:	35%	##### %NBS from IEP below	If IEP not used, please detail assessment methodology:	Bracing calculation
	Assessed %NBS after e'quakes:	35%			
Across	Assessed %NBS before e'quakes:	100%	##### %NBS from IEP below		
	Assessed %NBS after e'quakes:	100%			

GHD

GHD Building
226 Antigua Street, Christchurch 8013
T: 64 3 378 0900   F: 64 3 377 8575   E: chcmail@ghd.com

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Final	Kevan O Brien	Derek Chinn		Nick Waddington		7/12/2012