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Haybarn
PRK 2561 BLDG 005

Detailed Engineering Evaluation
Qualitative Report
Version Final

75 Lower Styx Road, Bottle Lake

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75 Lower Styx Road, Bottle Lake

Christchurch City Council

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Date
15th May 2013

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Haybarn

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Detailed Engineering Evaluation

Qualitative Report - SUMMARY

Version Final

75 Lower Styx Road, Bottle Lake, Christchurch

Background

This is a summary of the Qualitative report for the building structure, and is based in part on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011 and visual inspections on 16th April 2012.

Building Description

The haybarn is located at 75 Lower Styx Road, Bottle Lake, Christchurch. The exact date of construction of the original building is unknown but the entire building was rebuilt in 1974. The building is currently used for storage of hay. There are 6 buildings located on the site with various uses.

The building is of timber frame construction. The roof of the building is corrugated iron on timber purlins. The timber purlins rest on the timber framed walls to the rear of the building and a timber beam and post frame system along the front of the building. Intermediate support is provided by a timber beam and post frame system. External walls along the rear and both sides of the building are timber framed with metal cladding to the exterior and no internal linings. The front edge of the building is open with timber posts providing support for the timber beams. There is no floor system in the building. Foundations are concrete strip footings to the perimeter walls.

Key Damage Observed

- No earthquake related damage was noted to the building.
- Cracking was noted to one of the timber posts along the front of the building. It is suspected that this damage is as a result of an impact with a vehicle.

Critical Structural Weaknesses

The following potential critical structural weaknesses have been identified in the structure.

- Plan Irregularity (30% Reduction)
- Existing Damage (10% Reduction)

47% NBS

Indicative Building Strength (from IEP and CSW assessment)

Based on the information available, and using the NZSEE Initial Evaluation Procedure, the original capacity of the building has been assessed to be in the order of 47% NBS and post-earthquake capacity also in the order of 47% NBS. The building's post-earthquake capacity excluding critical structural weaknesses is in the order of 75% NBS.

The building has been assessed to have a seismic capacity in the order of 47% NBS and is therefore considered to be potentially Earthquake Risk.

Recommendations

The recent seismic activity in Christchurch has caused no visible damage to the building. As the building has achieved between 34% NBS and 67% NBS following a qualitative Detailed Engineering Evaluation of the building, further assessment is not required. However, GHD recommended that a quantitative assessment be carried out and if necessary strengthening options explored.

The building can remain occupied as it is not considered to be a potentially Earthquake Prone building.

1. Background

GHD has been engaged by the Christchurch City Council (CCC) to undertake a detailed engineering evaluation of the haybarn at 75 Lower Styx Road.

This report is a Qualitative Assessment of the building structure, and is based in part on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011.

A qualitative assessment involves inspections of the building and a desktop review of existing structural and geotechnical information, including existing drawings and calculations, if available.

The purpose of the assessment is to determine the likely building performance and damage patterns, to identify any potential critical structural weaknesses or collapse hazards, and to make an initial assessment of the likely building strength in terms of percentage of new building standard (%NBS).

At the time of this report, no intrusive site investigation, detailed analysis, or modelling of the building structure had been carried out. Construction drawings were made available, and these have been considered in our evaluation of the building. The building description is based on a review of the drawings and our visual inspections.

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

The building is the haybarn located at 75 Lower Styx Road, Bottle Lake, Christchurch. The exact date of construction of the original building at this site is unknown but the entire building was rebuilt in 1974. The building is currently used for storage of hay. There are 6 buildings located on the site with various uses.

The building is of timber frame construction. The roof of the building is corrugated iron on timber purlins. The spacing of the purlins is 0.9m centres as indicated in Figure 2. The timber purlins rest on the timber framed walls to the south-west and timber beams along the north-east side of the building. Intermediate support is provided by the central timber beams as shown in Figure 2. External walls along the north-west, south-west and the south-east are timber framed with metal cladding to the exterior and no internal linings. The north-east side of the building is open with a timber post providing support for the timber beams. There is no floor system in this building. Foundations are concrete strip footings to the north-east, south-east and the south-west perimeter. The timber posts are supported by concrete pile foundations.

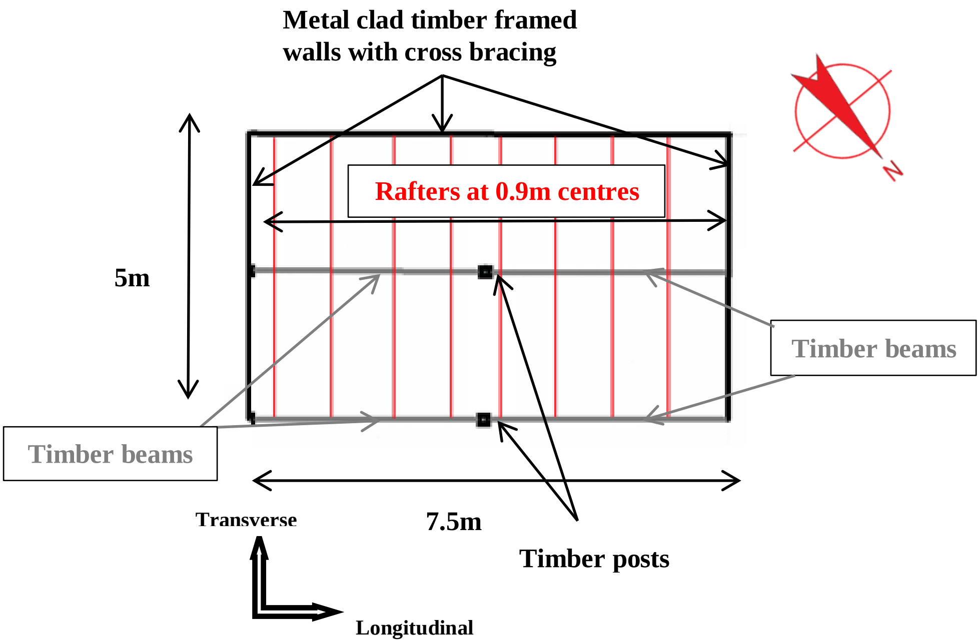

Figure 2 Plan Sketch Showing Key Structural Elements

The dimensions of the building are approximately 7.5m in length, 5m in width and 2.8m in height. The plan area of the building is approximately 38m^2.

The nearest building to the haybarn is the storage shed approximately 4m to the north-east. The closest waterway is the Styx River approximately 40m to the south-west. The site is predominantly flat with insignificant variations in the ground levels throughout.

4.2 Gravity Load Resisting System

Gravity loads are transferred from the metal roof cladding to the timber rafters running in the transverse direction of the building and then onto the timber framed external wall and the timber beams. Gravity loads in the external timber framed walls are transmitted through to the concrete perimeter strip foundations and into the ground. Gravity loads transferred to the timber beams are transferred to the timber posts and down to the concrete piles.

There is no floor slab and as a result of this internal gravity loads are transferred directly to the ground.

4.3 Lateral Load Resisting System

4.3.1 Longitudinal

The primary lateral load path in the longitudinal direction of the building is from the roof cladding, to the rafters, back to the timber framed rear wall of the building, on to the strip footings and finally to the ground below.

The roof cladding, rafters and joists combine to form a roof diaphragm which will transfer the majority of the lateral loading to the rear wall of the building. No cross bracing was seen in the roof of the building. Loads are then transferred to the ground through sheet bracing action of the metal cladding. Similarly to the roof, it is expected that the metal cladding fixed to the timber frame will provide some diaphragm action. Cross bracing in the rear wall was clearly visible and is expected to aid the transfer of lateral loads down through the wall. Secondary lateral load resistance is provided by the timber beam and post frame system along the centre line and the front of the building. Knee bracing help to create a moment frame system. Torsional effects are resisted by the metal clad side walls.

4.3.2 Transverse

Nominal roof bracing, achieved through the roof cladding, transfers the lateral loads back to the side walls. Timber diagonal wall bracing (aided by the cladding) transfers the lateral loads to the foundations

5. Assessment

An inspection of the building was undertaken on the 16th of April 2012. Both the interior and exterior of the building were inspected.

The inspection consisted of scrutinising 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 the IEP procedure described by the NZSEE and based on the information obtained from visual observation of the building and available drawings.

6. Damage Assessment

6.1 Surrounding Buildings

The haybarn at 75 Lower Styx Road is located in a rural area with 5 other buildings. These buildings are a dwelling, a garage, a storage shed, a dairy unit and a barn. There did not appear to be any earthquake-related damage to any of these structures.

6.2 Residual Displacements and General Observations

No residual displacements of the structure were noticed during our inspection of the building.

The only damage noted to the building was cracking to the timber posts along the north-east of the building but this is not believed to be a result of the earthquakes. As this damage is considered to adversely affect the load carrying capacity of the structural system, a 5% reduction of the % NBS will be applied.

6.3 Ground Damage

There was no evidence of ground damage on the property. Neighbouring land to the southwest, at 51 Lower Styx Road, was severely affected by lateral spreading.

7. Critical Structural Weakness

7.1 Short Columns

No significant short columns are present in the structure.

7.2 Lift Shaft

The building does not contain a lift shaft.

7.3 Roof

No roof bracing was seen. Roof elements such as cladding and roof joists are expected to provide minimal bracing to the roof structure in the form of diaphragm action. The lack of visible bracing in conjunction with no front wall constitutes a plan irregularity critical structural weakness (section 7.6).

7.4 Staircases

The building does not contain a staircase.

7.5 Site Characteristics

Based on the findings of the geotechnical appraisal it was found that the site has a moderate to high potential for liquefaction. As the building is timber framed and able to accommodate some movement, for the purposes of the IEP assessment of the building and the determination of the %NBS score, the effects of soil liquefaction on the performance of the building has been assessed as an ‘insignificant’ site characteristic in accordance with the NZSEE guidelines.

7.6 Plan Irregularity

The presence of a large opening in the front face of the building along with only nominal roof diaphragm causes a significant plan irregularity critical structural weakness.

8. Geotechnical Consideration

8.1 Site Description

The site at 75 Lower Styx Road is situated in Bottle Lake, just north of Christchurch City. It is situated between the Styx River and Lower Styx Road, and is relatively flat at approximately 3m above mean sea level. It is approximately 4km south of the Waimakariri River, and 4km west of the coast (Pegasus Bay).

8.2 Published Information on Ground Conditions

8.2.1 Published Geology

The geological map of the area[1] indicates that the site to be on or near the boundary of the following units:

- grey river alluvium, comprising gravel, sand and silt, in active floodplains, Holocene in age; and,
- beach sand or river sand dunes, Holocene in age.

8.2.2 Environment Canterbury Logs

Information from Environment Canterbury (ECan) indicates that three boreholes are located within a 200m radius of the site. Of these boreholes, two of them had lithographic logs (see Table 2), which indicate the area is typically underlain by 30m of sand and gravel. The logs also indicate the potential presence of strata containing peat at approximately 27m below ground level (bgl).

Table 2 ECan Borehole Summary

Bore Name	Log Depth	Groundwater	Distance & Direction from Site
M35/9747	30.0m	0.30m bgl	150m NE of the site
M35/11929	32.5m	0.72m bgl	150m SW of the site

It should be noted that the purpose of the boreholes the well logs are associated with, were sunk for groundwater extraction and not for geotechnical purposes. Therefore, the amount of material recovered and available for interpretation and recording will have been variable at best and may not be representative. 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.

8.2.3 EQC Geotechnical Investigations

The Earthquake Commission has not undertaken geotechnical testing in the area of the subject site.

[1] Forsyth P.J., Barrell D.J.A., & Jongens R. 2008: *Geology of the Christchurch Area*. Institute of Geological and Nuclear Sciences 1:250,000 Geological Map 16. Lower Hutt. Institute of Geological and Nuclear Sciences Limited.

8.2.4 Land Zoning

Canterbury Earthquake Recovery Authority (CERA) has published areas showing the Green Zone Technical Category in relation to the risk of future liquefaction and how these areas are expected to perform in future earthquakes.

The site is classified as Green Zone, indicating the land is generally suitable for repair and rebuilding to take place. It is also categorised Technical Category Not Applicable (rural & unmapped), as the property is considered non-residential.

8.2.5 Post February Aerial Photography

Aerial photography taken following the 22 February 2011 earthquake doesn't show clear signs of liquefaction (see Figure 3), however, liquefaction was observed close to the property.

Figure 3 Post February 2011 Earthquake Aerial Photography [2]

8.2.6 Summary of Ground Conditions

From the information presented above, the ground conditions underlying the site are anticipated to comprise beach sands and gravels. However, due to the limited information available, this is subject to confirmation.

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

8.3 Seismicity

8.3.1 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 3 Summary of Known Active Faults[34]

Known Active Fault	Distance from Site	Direction from Site	Max Likely Magnitude	Avg Recurrence Interval
Alpine Fault	130 km	NW	~8.3	~300 years
Greendale (2010) Fault	30 km	SW	7.1	~15,000 years
Hope Fault	100 km	N	7.2~7.5	120~200 years
Kelly Fault	110 km	NW	7.2	150 years
Porters Pass Fault	60 km	NW	7.0	1100 years

Recent earthquakes since 22 February 2011 have identified the presence of a previously unmapped active fault system underneath Christchurch City and the Port Hills. Research and published information on this system is in development and not generally available. Average recurrence intervals are yet to be estimated.

8.3.2 Ground Shaking Hazard

This seismic activity has produced earthquakes of Magnitude-6.3 with peak ground accelerations (PGA) up to twice the acceleration due to gravity (2g) in some parts of the city. This has resulted in widespread liquefaction throughout Christchurch.

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.

In addition, anticipation of marine and/or estuarine sands of varying density, a 475-year PGA (peak ground acceleration) of ~0.4 (Stirling et al, 2002[4]), and bedrock anticipated to be in excess of 500m deep, and hence ground shaking is likely to be relatively high.

8.4 Slope Failure and/or Rockfall Potential

Given the site's location in a flat area northeast of Christchurch, global slope instability is considered negligible. However, the Styx River may be susceptible to lateral spreading, as evident to the north in Spencerville following the 4th September 2010 and 22nd February 2011 earthquakes.

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3 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, pp 1878-1903, June 2002.

4 GNS Active Faults Database

In addition, any localised retaining structures or embankments should be further investigated to determine the site-specific slope instability potential.

8.5 Liquefaction Potential

Due to the anticipated presence of sand at the shallow depth, and the sites proximity to a local water course, it is considered possible that liquefaction will occur at the site. It is not clear from the post-earthquake aerial photography (Figure 3) whether liquefaction has occurred at the site, however, it was observed close to the property. The site is considered to have a moderate-high liquefaction potential at this stage of investigation.

This liquefaction may occur in the form of sand boils, lateral spreading or both.

Ground Investigation should be undertaken to establish the liquefaction potential of the site and allow a comprehensive liquefaction assessment to be undertaken.

8.6 Recommendations

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

It is recommended that three piezocone CPTs be conducted to target depths of 20m. This will allow a liquefaction assessment to be carried out.

8.7 Conclusions & Summary

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 is anticipated to be situated predominantly on sand and gravel. Associated with this the site also has a moderate-high liquefaction potential. This may also arise in the form of lateral spreading on the Styx River.

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

It is recommended that intrusive investigation comprising three piezocone CPTs be conducted to target depths of 20m.

9. Survey

No level or verticality surveys have been undertaken for this building at this stage in accordance with Christchurch City Council guidelines.

10. Initial Capacity Assessment

10.1 % NBS Assessment

The building's capacity was assessed using the Initial Evaluation Procedure based on the information available. The building's capacity excluding critical structural weaknesses and the capacity of any identified weaknesses are expressed as a percentage of new building standard (%NBS) and are in the order of that shown below in Table 4. These capacities are subject to confirmation by a more detailed quantitative analysis.

Item	%NBS
Building excluding CSW's	75
Plan Irregularity (30% Reduction) Existing Damage (10% Reduction)	47

Table 4 Indicative Building and Critical Structural Weaknesses Capacities based on the NZSEE Initial Evaluation Procedure

Following an IEP assessment, the building has been assessed as achieving 47% New Building Standard (NBS). Under the New Zealand Society for Earthquake Engineering (NZSEE) guidelines the building is considered potentially Earthquake Risk as it achieves greater than 34% NBS and less than 67% NBS. The existing damage to the building is believed to adversely affect the load carrying capacity and as a result the % NBS of the building has had a further 5% Reduction applied to it.

10.2 Seismic Parameters

The seismic design parameters based on current design requirements from NZS 1170:2002 and the NZBC clause B1 for this building are:

- Site soil class: D, NZS 1170.5:2004, Clause 3.1.3, Soft Soil
- Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011
- Return period factor R_u = 0.5, NZS 1170.5:2004, Table 3.5, Importance level 1 structure with a 50 year design life.

An increased Z factor of 0.3 for Christchurch has been used in line with requirements from the Department of Building and Housing resulting in a reduced % NBS score.

10.3 Expected Structural Ductility Factor

A structural ductility factor of 2 has been assumed based on the structural system observed and the date of construction.

10.4 Discussion of Results

The results obtained from the initial IEP assessment are consistent with those expected for a building of this age and construction type. The building was constructed prior to 1975 and would have been designed to the standards at the time, NZS 1900: 1964. This standard would have used design loads significantly less than those required by current loading standard. When combined with the increase in the hazard factor for Christchurch to 0.3, it would be expected that the building would not achieve 100% NBS. Due to the presence of a critical structural weakness in the form of plan irregularity, it is reasonable to expect the building to be classified as potentially Earthquake Risk.

10.5 Occupancy

As the building has been found to have a % NBS greater than 34% but less than 67%, it is deemed as potentially Earthquake Risk. The structure can remain occupied as it has not been identified as a potentially earthquake prone building.

11. Initial Conclusions

The building has been assessed to have a seismic capacity in the order of 47% NBS and is therefore potentially Earthquake Risk in accordance with the NZSEE guidelines. It is recommended that the building may remain occupied.

12. Recommendations

The recent seismic activity in Christchurch has caused no visible damage to the building. The building can remain occupied as it is not considered to be a potentially Earthquake Prone building. However, as the building has not achieved 67% NBS or higher, GHD recommend that a quantitative assessment and geotechnical investigation be carried out and if necessary strengthening options explored.

13. Limitations

13.1 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 surveys have been undertaken.
- No material testing has been undertaken.
- No calculations, other than those included as part of the IEP in the CERA Building Evaluation Report, have been undertaken. No modelling of the building for structural analysis purposes has been performed.

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.

13.2 Geotechnical Limitations

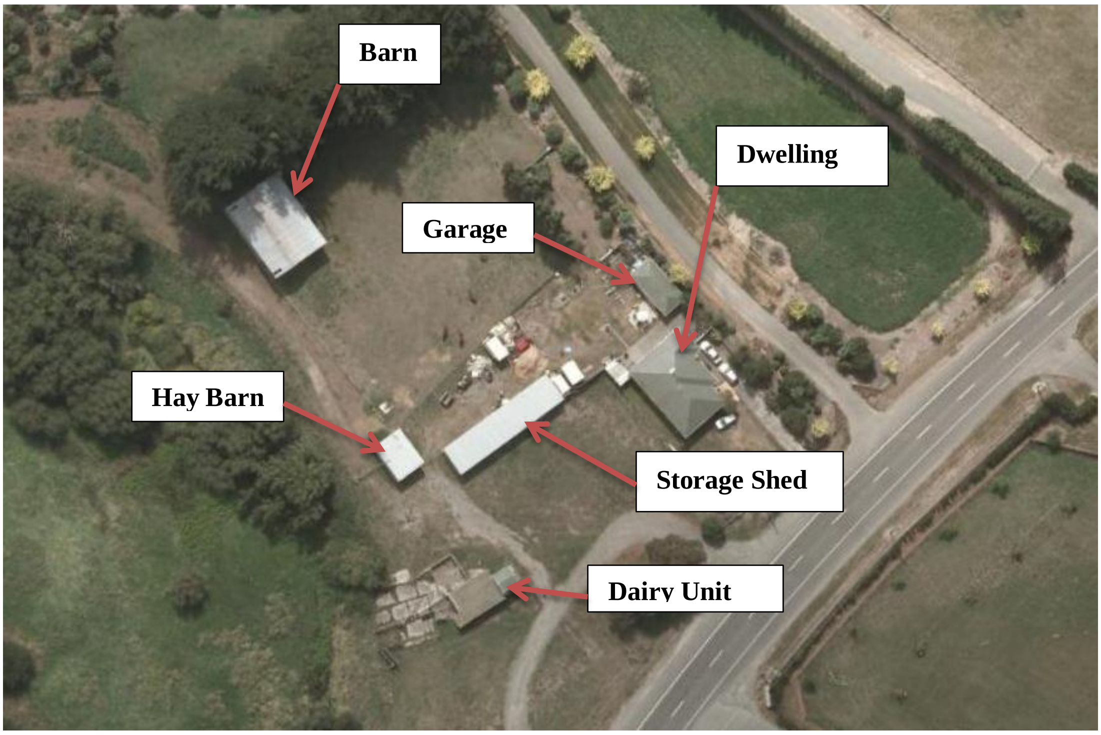
This report presents the results of a geotechnical appraisal prepared for the purpose of this commission, and for prepared solely for the use of Christchurch City Council and their advisors. The data and advice provided herein relate only to the project and structures described herein and must be reviewed 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 Aerial photograph of site at 75 Lower Styx Road.

Photograph 2 View of the front of the haybarn. A large opening is clearly visible.

Photograph 3 View of the side wall of the haybarn.

Photograph 4 View of the exterior of the rear wall of the haybarn.

Photograph 5 Timber beam and post system on the front and centre of the building showing the knee connection. Lack of roof sarking is clearly visible.

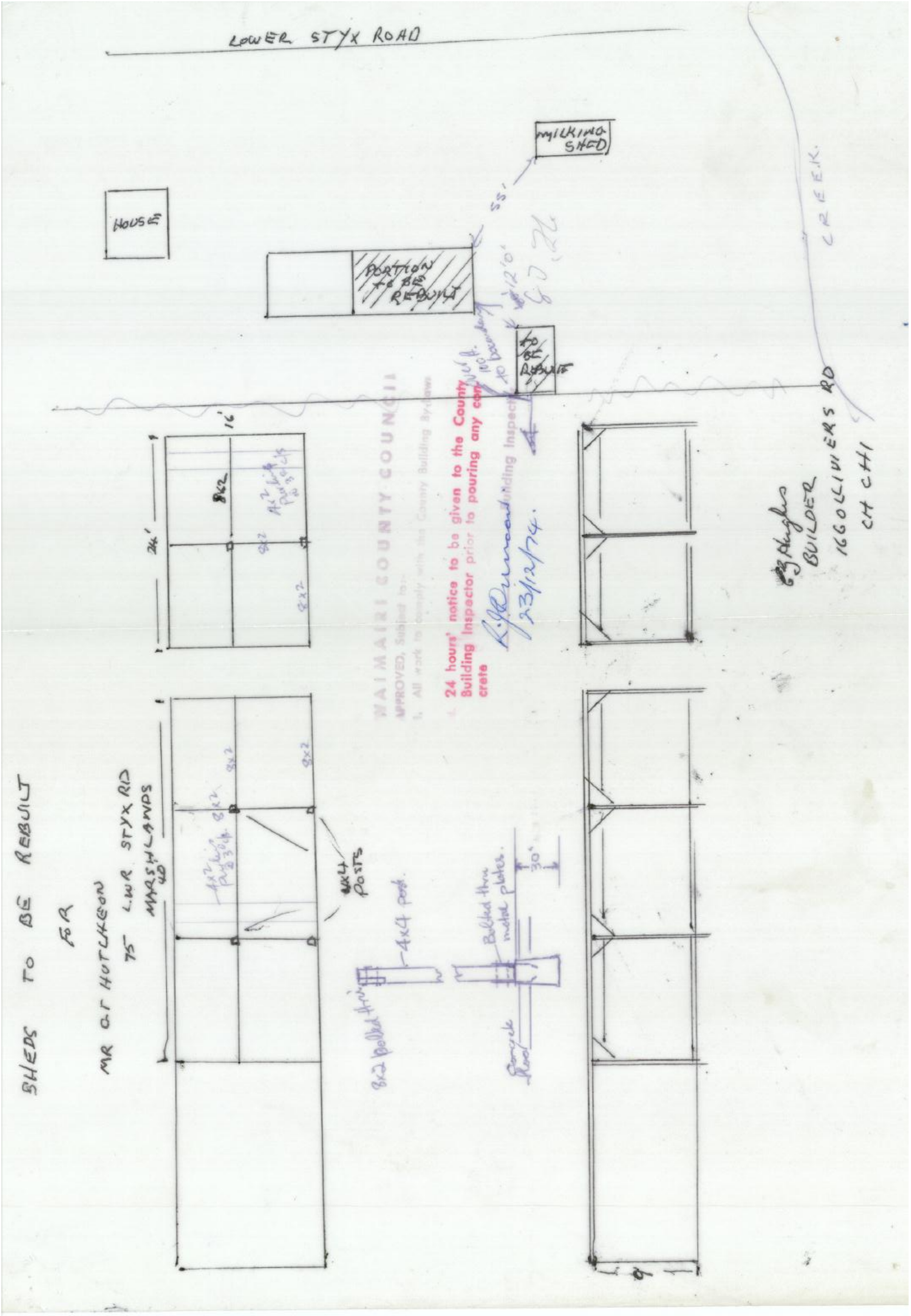
Photograph 6 Timber framed wall to the rear showing timber cross bracing.

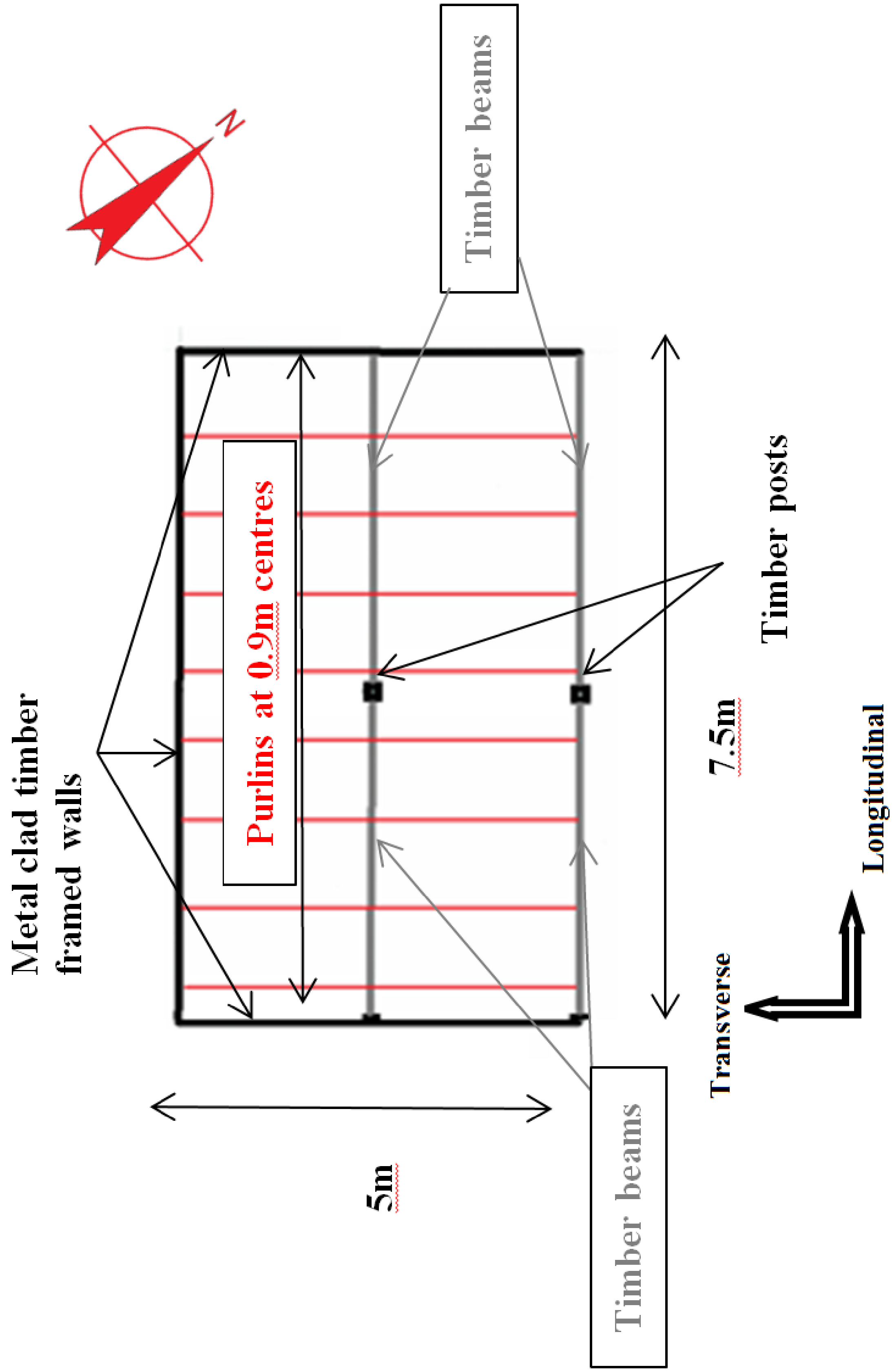
Photograph 7 Concrete strip footing foundations to the perimeter walls.

Photograph 8 Cracked timber support post.

Appendix B

Existing Drawings


LOWER STYX ROAD
HOUSE
MILKING SHED
PORTION to BE REBUILT
CREEK
SHEDS TO BE REBUILT
FOR
75 LWR STYX RD
MARSHLANDS
WAIMAIRI COUNTY COUNCIL
24 hours' notice to be given to the County Building Inspector prior to pouring any concrete
BUILDER
166 OLLIVIERS RD
CH CH


N
Timber beams
Metal clad timber framed walls
Purlins at 0.9m centres
Timber posts
7.5m
Longitudinal
Transverse
5m
Timber beams

Appendix C

CERA Building Evaluation Form

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Haybarn			Reviewer:	Stephen Lee
	Unit	No:	Street	CPEng No:	1006840
Building Address:	5	75	Lower Styx Road	Company:	GHD
Legal Description:	Lot 1 DP 4410			Company project number:	513059666
				Company phone number:	(03) 3780900
	Degrees	Min	Sec		
GPS south:	43	27	18.31	Date of submission:	14/05/2013
GPS east:	172	39	57.60	Inspection Date:	16/04/12
				Revision:	Final
Building Unique Identifier (CCC):	PRK 2561 BLDG 005			Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	0
Soil type:	mixed	Soil Profile (if available):	Gravel Sand and Silt
Site Class (to NZS1170.5):	D		
Proximity to waterway (m, if <100m):	45	If Ground improvement on site, describe:	n/a
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	3.00

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	3.00
Ground floor split?	no		Ground floor elevation above ground (m):	0.00
Storeys below ground	0			
Foundation type:	strip footings		if Foundation type is other, describe:	
Building height (m):	2.80		height from ground to level of uppermost seismic mass (for IEP only) (m):	2.6
Floor footprint area (approx):	35			
Age of Building (years):	38		Date of design:	1965-1976
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	other (specify)		Brief strengthening description:	
Use (upper floors):	other (specify)			
Use notes (if required):	Haybarn			
Importance level (to NZS1170.5):	IL1			

<u>Gravity Structure</u>

Gravity System:	frame system		
Roof:	timber framed	rafter type, purlin type and cladding	
Floors:	concrete flat slab	slab thickness (mm)	150
Beams:	timber	type	200x50mm
Columns:	timber	typical dimensions (mm x mm)	75x75
Walls:	Timber Framed	thickness (mm)	100

<u>Lateral load resisting structure</u>

Lateral system along:	lightweight timber framed walls	**Note: Define along and across in**	note typical wall length (m)	22

Ductility assumed, μ:	2.00	**detailed report!**		
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		note typical wall length (m)	16
Ductility assumed, μ:	2.00			
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:	profiled metal	describe	Corrugated Iron
Roof Cladding:	Metal	describe	Corrugated Iron
Glazing:			
Ceilings:	none		Asbestos
Services(list):			

Available documentation

Architectural	partial	original designer name/date	Unknown, 1974
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:	Good	Describe damage:	
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:	green		
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	
	Describe (summary):	No damage		
Across	Damage ratio:	0%		
	Describe (summary):	No damage		

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

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

Recommendations

Level of repair/strengthening required:	significant structural and strengthening	Describe:	
Building Consent required:	yes	Describe:	
Interim occupancy recommendations:	partial occupancy	Describe:	

Along	Assessed %NBS before:	47%	47% %NBS from IEP below	If IEP not used, please detail assessment methodology:
	Assessed %NBS after:	47%		
Across	Assessed %NBS before:	47%	47% %NBS from IEP below	
	Assessed %NBS after:	47%		

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): 1965-1976

h_n from above: 2.6m

Seismic Zone, if designed between 1965 and 1992: B

not required for this age of building

not required for this age of building

	along	across
Period (from above):	0.4	0.4
(%NBS)nom from Fig 3.3:	5.0%	5.0%

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 $(\%NBS)_{nom}$:	**5%**	**5%**

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	
Hazard scaling factor, **Factor B:**	3.333333333

2.4 Return Period Scaling Factor

Building Importance level (from above):	1
Return Period Scaling factor from Table 3.1, **Factor C**:	2.00

		along	across
2.5 Ductility Scaling Factor	Assessed ductility (less than max in Table 3.2)	2.00	2.00
	Ductility scaling factor: =1 from 1976 onwards; or =kμ, if pre-1976, fromTable 3.3:	1.57	1.57
	Ductiity Scaling Factor, **Factor D**:	1.57	1.57
2.6 Structural Performance Scaling Factor:	Sp:	0.700	0.700
	Structural Performance Scaling Factor **Factor E**:	1.428571429	1.428571429
2.7 Baseline %NBS, $(NBS\%)_b = (\%NBS)_{nom}$ x A x B x C x D x E	**$\%NBS_b$:**	**75%**	**75%**

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

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

		Along	Across
3.6. Other factors, Factor F	For ≤ 3 storeys, max value =2.5, otherwise max valule =1.5, no minimum	0.9	0.9
	Rationale for choice of F factor, if not 1	10% reduction for existing damage	10% reduction for existing damage

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)		**0.63**	**0.63**
4.3 PAR x (%NBS)b:	PAR x Baselline %NBS:	**47%**	**47%**
4.4 Percentage New Building Standard (%NBS), (before)			**47%**

Official Use only:

Accepted By
Date:

GHD

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Final	Peter O'Brien	Cormac Joy		Stephen Lee		15/5/13