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Iron Clad Barn
PRK 2635 BLDG 005

Detailed Engineering Evaluation

Qualitative Report

Version Final

51 Lower Styx Road, Styx River Reserve

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

Iron Clad Barn

PRK 2635 BLDG 005

Detailed Engineering Evaluation
Qualitative Report
Version Final

51 Lower Styx Road, Styx River Reserve

Christchurch City Council

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Date
23rd May 2013

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Qualitative Report Summary

Iron Clad Barn

PRK 2635 BLDG 005

Detailed Engineering Evaluation

Qualitative Report - SUMMARY

Version Final

51 Lower Styx Road, Styx River Reserve, Christchurch

Background

This document is a summary of the Qualitative report for the above 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 'Iron Clad Barn' is located at 51 Lower Styx Road, Styx River Reserve, Christchurch. It was constructed in 1990's. The building is currently used for storage purposes.

The building is of lightweight timber frame construction. The roof structure consists of lightweight steel roofing fixed to timber rafters. The walls are ply cladding and the foundations are concrete slab on grade.

Key Damage Observed

No damage was observed during the site inspection.

Critical Structural Weaknesses

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

- Liquefaction Probable (30% reduction)
- Plan Irregularity (30% reduction)

} →50% 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 50% NBS and post-earthquake capacity is also in the order of 50% NBS. The building's post-earthquake capacity excluding critical structural weaknesses is in the order of 102% NBS.

The building has been assessed to have a seismic capacity in the order of 50% NBS and is therefore considered to be potentially Earthquake Risk, but is not potentially Earthquake Prone.

Recommendations

As the building has achieved more than 33% NBS, CCC are not required to undertake a detailed seismic assessment.

The building is currently unoccupied, however, as the building has achieved greater than 33% NBS it is not considered to be an earthquake prone structure and can be occupied.

1. Background

GHD has been engaged by the Christchurch City Council (CCC) to undertake a detailed engineering evaluation of the Iron Clad Barn at 51 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 located at 51 Lower Styx Road, Styx River Reserve, Christchurch. It is estimated that the building was constructed in in the 1990’s (between 1992 and 2004). The building is owned by the Christchurch City Council and is not currently in use. There are seven other buildings located on the site with various uses and other reports address these other buildings.

- The building has a mono pitch corrugated steel roof supported on timber purlins 8/5 and timber rafters 30/5 ($30/4^5$) which span in the transverse direction (no cross bracing is evident in the roof structure). The rafters are supported by timber frame wall structure cladded by the corrugated steel.
- Floor is unreinforced concrete slab on grade with no apparent perimeter thickening

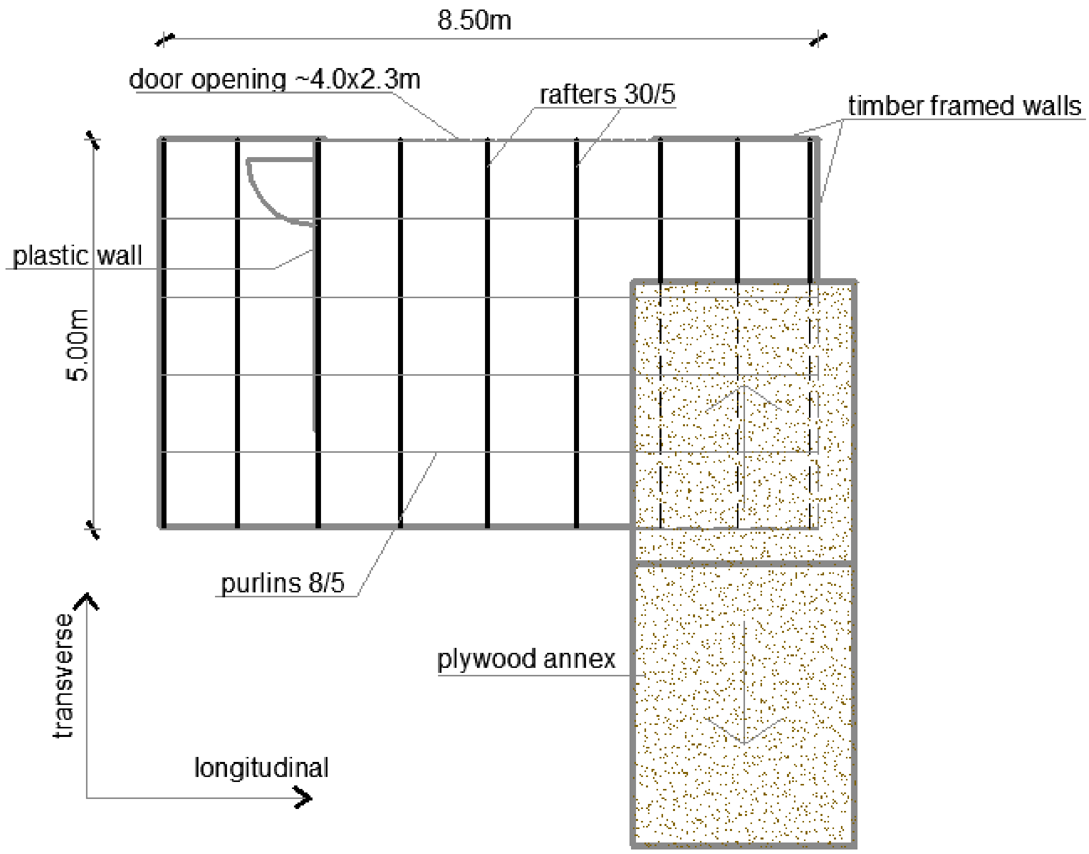


Figure 2 Plan Sketch Showing Key Structural Elements

The building dimensions are 8.5m in length, 5m in width and 2.70m in height. The plan area of the building is approximately $43m^2$.

The nearest building to the Iron Clad Barn is the Aviary and Fowl house, approximately 3m to the south. The closest waterway is the Styx River approximately 15m to the west.

The site slopes approximately 1.5m between Lower Styx Road and the Styx River.

4.2 Gravity Load Resisting System

Gravity loads are transferred from the roof cladding to the purlins which span in longitudinal directions. The purlins are supported by the timber rafters which span in the transverse direction between the external timber walls. The rafters transfer the load to the timber frame walls. Vertical loads are then transferred down through the concrete floor slab to the ground below.

4.3 Lateral Load Resisting System

Lateral loads are transferred through the building similarly in both directions. Loads acting on the roof are transferred to the purlins, through to the rafters, back to the lateral load resisting walls, through to the foundations and into the ground below.

At roof level no cross bracing was visible. The combination of the roof cladding, timber purlins and rafters form some nominal diaphragm action, which provide significant bracing to the structure.

No diagonal wall bracing was visible in the walls and lateral load resistance in these walls is provided only by the fixings of the iron cladding to the timber studs.

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 at the iron clad, but internal inspection wasn't done for plywood annex.

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.

6. Damage Assessment

6.1 Surrounding Buildings

The Iron Clad Barn at 51 Lower Styx Road is located in a rural area with 7 other buildings.

These buildings are:

- Double Garage- some cracking of the perimeter strip foundations.
- Single garage - significant cracking of the slab on grade foundation and lateral displacement of the wall.
- Dwelling - severely affected by the differential settlement and lateral displacement of the building.
- Aviary- not affected.
- Fowl House- not affected.
- Barn (Plywood Clad) – significant cracking of the slab on grade.
- Swimming pool- not affected.

6.2 Residual Displacements and General Observations

No damage was observed during the site inspection.

6.3 Ground Damage

The site was severely affected by the lateral spreading and differential settlement as the site has slumped towards the Styx River.

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 cross bracing was visible in the roof of the building. The roof elements (cladding, purlins and timber rafters) are expected to combine to provide nominal roof bracing.

7.4 Staircases

There is no staircase in the building.

7.5 Site Characteristics

The site is severely affected by lateral spreading and differential settlement. Following the geotechnical appraisal it was found that the site has a significant potential for liquefaction. As the building has a concrete slab on grade foundation, the effects of liquefaction are likely to adversely affect the structure of the building. 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 a 'significant' site characteristic in accordance with the NZSEE guidelines.

7.6 Plan Irregularity

The presence of a large opening in the front wall despite the satisfying roof bracing constitutes a 'significant' critical structural weakness.

8. Geotechnical Consideration

8.1 Site Description

The subject site is situated immediately to the east of the Styx River, within the suburb of Bottle Lake to the north of Christchurch. It is relatively flat at approximately 6m 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 is on or near the boundary of the following units:

- Grey river alluvium beneath plains or low-level terraces (Q1a), Holocene in age; and,
- Stabilised beach sand or river sand dunes (Q1d), Holocene in age.

8.2.2 Environment Canterbury Logs

Information from Environment Canterbury (ECan) indicates that one borehole is located within 230m of the site (see Table 1). The bore log indicates the ground to be underlain by sand layers to ~6m below ground level (bgl), clay sand, sand and gravelly sand to 19m bgl, with “pug” underlying the sand. An additional borehole over 300m to the south of the site indicates sand to ~24m bgl.

Table 2 ECan Borehole Summary

Bore Name	Log Depth	Groundwater	Distance & Direction from Site
M35/11929	~32.5m	~0.72m bgl	230m NE

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.

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.

[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.

The site is classified as Technical Category Not Applicable (TC N/A), being non-residential properties in urban areas, properties in rural areas or those beyond the extent of land damage mapping.

8.2.5 Post February Aerial Photography

Aerial photography taken following the 22 February 2011 earthquake shows no signs of liquefaction visible within the property boundary as shown in Figure 3. However, liquefaction in the form of sand boils and lateral spreading is evident on the western side of the Styx River (subject property is to the east).

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 predominantly of sand with varying amounts of clay and gravel.

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.

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

Table 3 Summary of Known Active Faults[3,4]

Known Active Fault	Distance from Site	Direction from Site	Max Likely Magnitude	Avg Recurrence Interval
Alpine Fault	120 km	NW	8.3	~300 years
Greendale (2010) Fault	25 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 new active fault system / zone underneath Christchurch City and the Port Hills. Research and published information on this system is in development and not generally available and average recurrence intervals are yet to be estimated.

8.3.2 Ground Shaking Hazard

This recent 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 recent alluvial deposits, 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, ground shaking is expected to be moderate to high.

8.4 Slope Failure and/or Rockfall Potential

The topography surrounding the site is typically flat, rockfalls are not considered to be a hazard at this site. However, given the site's proximity to the Styx River, it is considered possible and likely that lateral spreading and/or river bank failure may occur.

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

[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

8.5 Liquefaction Potential

Due to the presence of alluvial and/or estuarine deposits, it is possible and likely that liquefaction will occur in layers where sands and silts are present. Evidence is visible of liquefaction to the west of the side (both sand boils and lateral spreading).

It is considered likely that lateral spreading will occur again in this area as a result of similar-size seismic events.

Further investigation is recommended to better determine subsoil conditions, and quantify the liquefaction potential of the soils directly under the site. From this, a more comprehensive liquefaction assessment could be undertaken.

8.6 Recommendations

Given the anticipated ground conditions and proximity to local waterways, we recommend that further investigation is undertaken. Specifically, two CPT investigations should be conducted to a target depth of 20m bgl. From this a numerical liquefaction assessment can be undertaken.

A soil class of **D** (in accordance with NZS 1170.5:2004) should be adopted for the site. This soil class can be confirmed following assessment of intrusive ground investigation data.

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 appears to be situated on recent alluvial deposits, comprising predominantly of sand with varying amounts of clay and gravel. Associated with this the site also has a moderate to high liquefaction potential.

Further investigation is recommended to enable a more comprehensive liquefaction and/or ground condition assessment to be undertaken. It is recommended that intrusive investigation comprising two piezocone CPT tests be conducted.

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

The site is also considered susceptible to lateral spreading along the Styx River.

9. Survey

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

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	102
Liquefaction Potential (30% Reduction) Plan Irregularity (30% Reduction)	50

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 50% New Building Standard (NBS). Under the New Zealand Society for Earthquake Engineering (NZSEE) guidelines the building is considered potentially Earthquake Risk, but not Earthquake Prone as it achieves more than 33% NBS and less than 67%.

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 2.0 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 lower than those expected for a building of this age and construction type. The building was constructed between 1992 and 2004 and was likely to have been designed in accordance with the loading standards of the time, NZS 4203:1992. The design loads used in this standard are less than those required by the 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 Critical Structural Weaknesses in the form of possible soil liquefaction and Plan Irregularity, it is reasonable to expect the building to be classified as Earthquake Risk.

10.5 Occupancy

As the building has achieved more than 33% NBS, CCC are not required to undertake a detailed seismic assessment.

The building is currently unoccupied, however, as the building has achieved greater than 33% NBS it is not considered to be an earthquake prone structure and can be occupied.

11. Initial Conclusions

The building has been assessed to have a seismic capacity in the order of 50% NBS and is therefore considered to be potentially Earthquake Risk, but not Earthquake Prone. As the building has achieved greater than 33% NBS, it is not considered to be an earthquake prone structure and can be occupied.

12. Recommendations

As the building has achieved more than 33% NBS, CCC are not required to undertake a detailed seismic assessment.

The building is currently unoccupied, however, as the building has achieved greater than 33% NBS it is not considered to be an earthquake prone structure and can be occupied.

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.

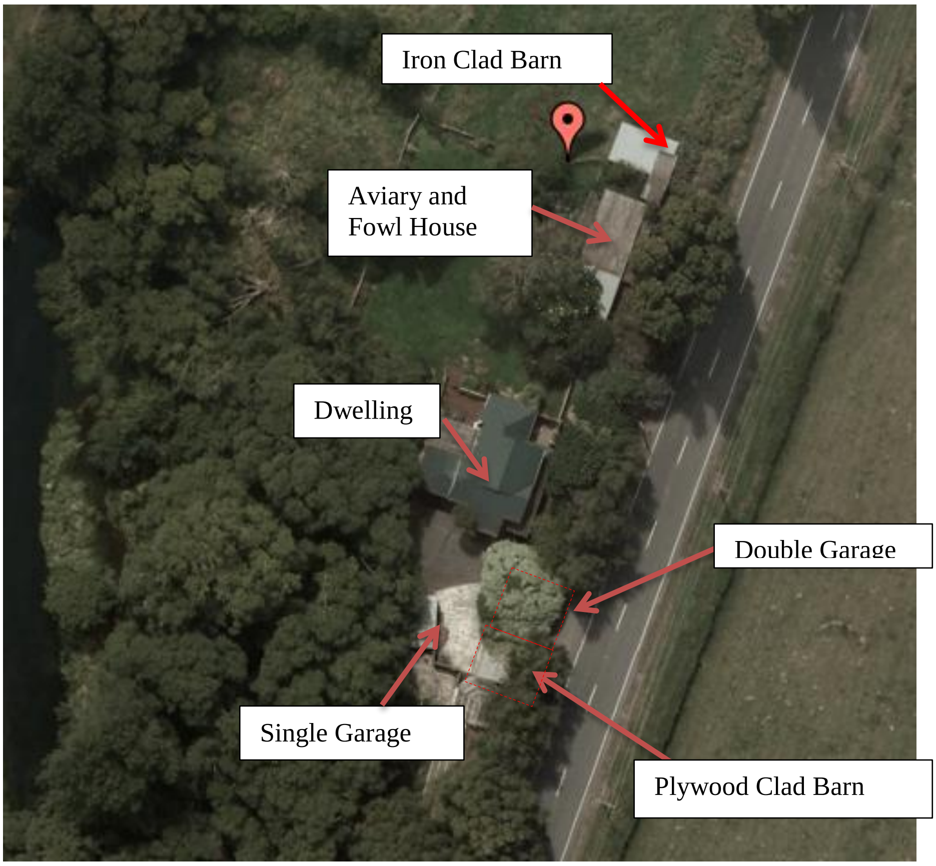
13.2 Geotechnical Limitations

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 51 Lower Styx Road.

Photograph 2 View of the Iron Clad Barn from the north.

Photograph 3 View of the Iron Clad Barn from the southwest.

Photograph 4 View of the annex of the Iron Clad Barn- view from the west.

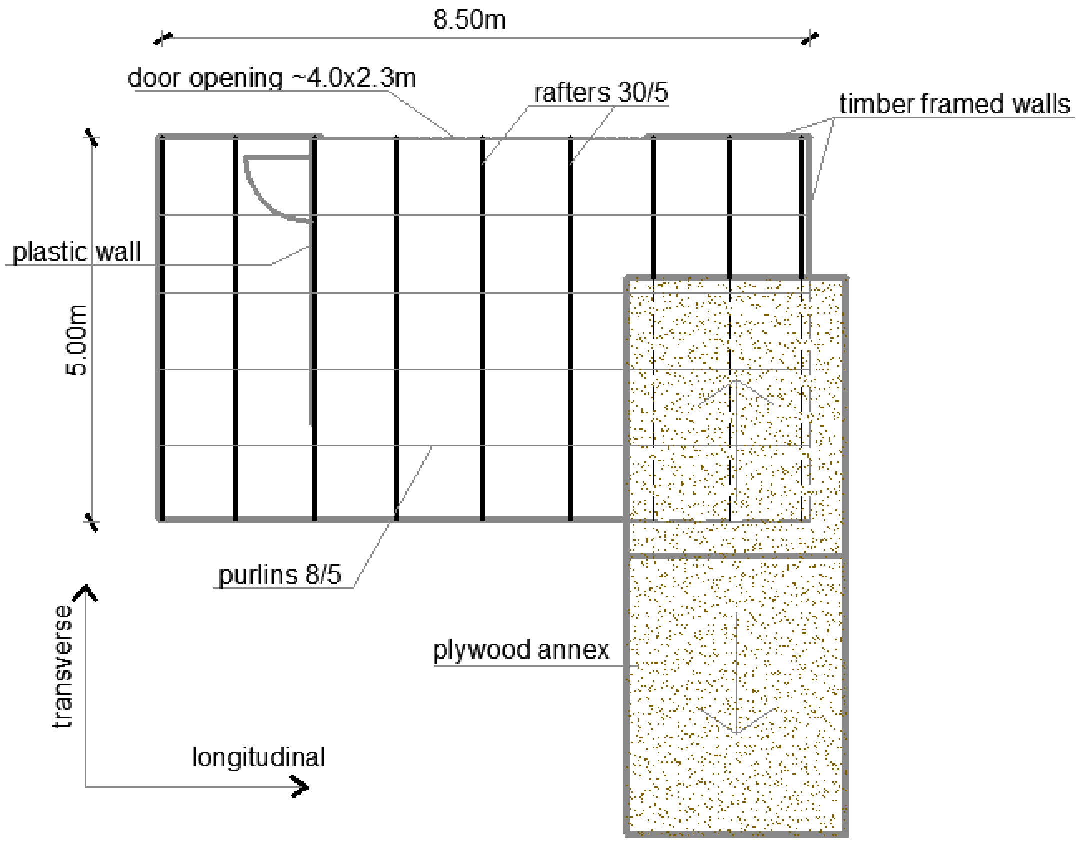
Photograph 5 Internal view of the building showing roof construction.

Photograph 6 Internal view of the building showing southwest corner

Photograph 7 Internal view of the building showing southeast corner

Appendix B

Existing Drawings


8.50m
door opening ~4.0x2.3m
rafters 30/5
timber framed walls
plastic wall
5.00m
purlins 8/5
plywood annex
transverse
longitudinal

Appendix C
CERA Building Evaluation Form

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Iron Clad			Reviewer:	Stephen Lee
	Unit	No:	Street	CPEng No:	1006840
Building Address:		51	Lower Styx Road	Company:	GHD
Legal Description:	Lot 8 DP 2769			Company project number:	513059658
				Company phone number:	(03) 3780900
	Degrees	Min	Sec		
GPS south:	43	33	48.15	Date of submission:	23/05/2013
GPS east:	172	42	31.73	Inspection Date:	15/04/2012
				Revision:	Final
Building Unique Identifier (CCC):	PRK 2635 BLDG 005			Is there a full report with this summary?	yes

Site

Site slope:	slope < 1in 10	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):	10	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):	1.00

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	1.00
Ground floor split?	no		Ground floor elevation above ground (m):	0.00
Storeys below ground				
Foundation type:	mat slab		if Foundation type is other, describe:	
Building height (m):	2.70		height from ground to level of uppermost seismic mass (for IEP only) (m):	2.7
Floor footprint area (approx):	42			
Age of Building (years):	15		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 unit			
Importance level (to NZS1170.5):	IL1			

Gravity Structure

Gravity System:	frame system		
Roof:	timber framed	rafter type, purlin type and cladding	timber
Floors:	concrete flat slab	slab thickness (mm)	
Beams:	timber	type	slab on grade
Columns:	timber	typical dimensions (mm x mm)	100x50
Walls:	non-load bearing	0	

Lateral load resisting structure

Lateral system along:	lightweight timber framed walls	**Note: Define along and across in**	8.5

Ductility assumed, μ:	2.00	**detailed report!**	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			5
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:	profiled metal	describe	Corrugated steel
Roof Cladding:	Metal	describe	
Glazing:			
Ceilings:	none		
Services(list):			

Available documentation

Architectural	none	original designer name/date	unknown, 1990's
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:	bad	Describe damage:	
Settlement:	100-200mm	notes (if applicable):	
Differential settlement:	1:150 or more	notes (if applicable):	
Liquefaction:	0-2 m³/100m²	notes (if applicable):	
Lateral Spread:	50-250mm	notes (if applicable):	
Differential lateral spread:	1:400-1:100	notes (if applicable):	
Ground cracks:	100-200mm/20m	notes (if applicable):	
Damage to area:	widespread to major (in in 3 to most)	notes (if applicable):	

Building:

	Current Placard Status:	red		
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:	0%		
	Describe (summary):			

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

Diaphragms	Damage?: no	Describe:
CSWs:	Damage?: yes	Describe: Site Characteristics
Pounding:	Damage?: no	Describe:
Non-structural:	Damage?: no	Describe:

Recommendations

Level of repair/strengthening required:	none	Describe:
Building Consent required:	yes	Describe:
Interim occupancy recommendations:	full occupancy	Describe:

Along	Assessed %NBS before e'quakes:	50%	50% %NBS from IEP below	If IEP not used, please detail assessment methodology:
	Assessed %NBS after e'quakes:	50%		
Across	Assessed %NBS before e'quakes:	50%	50% %NBS from IEP below	
	Assessed %NBS after e'quakes:	50%		

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: 2.7m

Seismic Zone, if designed between 1965 and 1992:

not required for this age of building: D soft soil

Design Soil type from NZS4203:1992, cl 4.6.2.2: b) Intermediate

	along	across
Period (from above):	0.4	0.4
(%NBS)nom from Fig 3.3:	22.3%	22.3%

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 $(\%NBS)_{nom}$:	**22%**	**22%**

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**:	1.20

		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**:	1.00	1.00
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	**$\%NBS_b$:**	**102%**	**102%**

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:		1
3.3. Short columns, Factor C:		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	significant	0.7

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	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)		**0.49**	**0.49**
4.3 PAR x (%NBS)b:	PAR x Baselline %NBS:	**50%**	**50%**
4.4 Percentage New Building Standard (%NBS), (before)			**50%**

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	Mirjana Hrnjak	Peter O'Brien	[signature]	Stephen Lee	[signature]	23/5/13