Linwood Community Crèche

BU 0836 002 EQ2

Detailed Engineering Evaluation

Quantitative Report

Christchurch City Council

Christchurch City Council

Linwood Community Crèche

Detailed Engineering Evaluation Quantitative Report

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Linwood Community Crèche Building
BU 0836-002 EQ2

Detailed Engineering Evaluation
Quantitative Report - SUMMARY
Final

136 Aldwins Road, Linwood

Background

This is a summary of the quantitative report for the building structure, and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011, visual inspections on 15 December 2011 and 19 January 2012, available drawings and calculations.

Key Damage Observed

Key damage observed includes:-

- Minor cracking to wall lining at the circular skylight;
- Cracking to the wall lining and slab at the interface between the new staff room and the main building.

Critical Structural Weaknesses

The lack of a ceiling diaphragm to the main indoor play area has been identified as a critical structural weakness, however it is expected that this will potentially lead to increased levels of damage to this area and not result in a collapse.

Indicative Building Strength (from quantitative assessment)

Based on the information available, and from undertaking a quantitative assessment, the building's original capacity has been assessed to be in the order of 40-60%NBS and post-earthquake capacity in the order of 40-60NBS. The building's post-earthquake capacity excluding critical structural weaknesses is in the order of 73%NBS. The building is therefore not classed as an earthquake prone building.

Recommendations

It is recommended that:

a) The current placard status of the building remains as green.

b) Strengthening works that would increase the overall seismic capacity of the building to at least 67% be developed.

c) If the CCC wish to further evaluate and quantify the liquefaction potential at this specific site, additional site testing comprising two CPT's and associated analysis would be required. Allowance should be made for predrilling of shallow gravels, if encountered, to complete CPT testing.

Contents

Executive Summary

Christchurch City Council appointed Opus International Consultants to carry out a detailed seismic assessment of the Linwood Community Crèche building in Linwood, Christchurch. The purpose of this assessment was to ascertain the anticipated seismic performance of the structure and to compare this performance with current design standards.

The lack of a ceiling diaphragm to the main indoor play area has been identified as a critical structural weakness, however it is expected that this will potentially lead to increased levels of damage to this area and not result in a collapse.

The seismic capacity of the building has been calculated as 40-60% NBS and the building is therefore not classed as earthquake prone.

Strengthening works addressing the issue of a lack of a ceiling diaphragm would increase the buildings overall seismic capacity to 73% NBS.

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Linwood Community Crèche building, located at 136 Aldwins Road, Linwood, Christchurch, following the M6.3 Christchurch earthquake on 22 February 2011.

The purpose of the assessment is to determine if the building is classed as being earthquake prone in accordance with the Building Act 2004.

The seismic assessment and reporting have been undertaken based on the quantitative procedures detailed in the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011.

2 Compliance

This section contains a brief summary of the requirements of the various statutes and authorities that control activities in relation to buildings in Christchurch at present.

2.1 Canterbury Earthquake Recovery Authority (CERA)

CERA was established on 28 March 2011 to take control of the recovery of Christchurch using powers established by the Canterbury Earthquake Recovery Act enacted on 18 April 2011. This act gives the Chief Executive Officer of CERA wide powers in relation to building safety, demolition and repair. Two relevant sections are:

Section 38 – Works

This section outlines a process in which the chief executive can give notice that a building is to be demolished and if the owner does not carry out the demolition, the chief executive can commission the demolition and recover the costs from the owner or by placing a charge on the owners' land.

Section 51 – Requiring Structural Survey

This section enables the chief executive to require a building owner, insurer or mortgagee to carry out a full structural survey before the building is re-occupied.

We understand that CERA 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 (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011. This document sets out a methodology for both initial qualitative and detailed quantitative assessments.

It is anticipated that a number of factors, including the following, will determine the extent of evaluation and strengthening level required:

1. The importance level and occupancy of the building.

2. The placard status and amount of damage.

3. The age and structural type of the building.

4. Consideration of any critical structural weaknesses.

We anticipate that any building with a capacity of less than 34% of new building standard (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67% as required by the CCC Earthquake Prone Building Policy.

2.2 Building Act

Several sections of the Building Act are relevant when considering structural requirements:

Section 112 - Alterations

This section requires that an existing building complies with the relevant sections of the Building Code to at least the extent that it did prior to the alteration.

This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council (CCC)) is satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'.

This is typically interpreted by CCC as being 67% of the strength of an equivalent new building. This is also the minimum level recommended by the New Zealand Society for Earthquake Engineering (NZSEE).

2.2.1 Section 121 – Dangerous Buildings

This section was extended by the Canterbury Earthquake (Building Act) Order 2010, and defines a building as dangerous if:

1. In the ordinary course of events (excluding the occurrence of an earthquake), the building is likely to cause injury or death or damage to other property; or
2. In the event of fire, injury or death to any persons in the building or on other property is likely because of fire hazard or the occupancy of the building; or
3. There is a risk that the building could collapse or otherwise cause injury or death as a result of earthquake shaking that is less than a 'moderate earthquake' (refer to Section 122 below); or
4. There is a risk that other property could collapse or otherwise cause injury or death; or
5. A territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone if its ultimate capacity would be exceeded in a 'moderate earthquake' and it would be likely to collapse causing injury or death, or damage to other property.

A moderate earthquake is defined by the building regulations as one that would generate loads 33% of those used to design an equivalent new building.

Section 124 – Powers of Territorial Authorities

This section gives the territorial authority the power to require strengthening work within specified timeframes or to close and prevent occupancy to any building defined as dangerous or earthquake prone.

Section 131 – Earthquake Prone Building Policy

This section requires the territorial authority to adopt a specific policy for earthquake prone, dangerous and insanitary buildings.

2.3 Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in 2006. This policy was amended immediately following the Darfield Earthquake on 4 September 2010.

The 2010 amendment includes the following:

1. A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
2. A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
3. A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
4. Repair works for buildings damaged by earthquakes will be required to comply with the above.

The council has stated their willingness to consider retrofit proposals on a case by case basis, considering the economic impact of such a retrofit.

If strengthening works are undertaken, a building consent will be required. A requirement of the consent will require upgrade of the building to comply 'as near as is reasonably practicable' with:

- The accessibility requirements of the Building Code.
- The fire requirements of the Building Code. This is likely to require a fire report to be submitted with the building consent application.

2.4 Building Code

The Building Code outlines performance standards for buildings and the Building Act requires that all new buildings comply with this code. Compliance Documents published by The Department of Building and Housing can be used to demonstrate compliance with the Building Code.

On 19 May 2011, Compliance Document B1: Structure was amended to include increased seismic design requirements for Canterbury as follows:

- 36% increase in the basic seismic design load for Christchurch (Z factor increased from 0.22 to 0.3);
- Increased serviceability requirements.

3 Earthquake Resistance Standards

For this assessment, the building's earthquake resistance is compared with the current New Zealand Building Code requirements for a new building constructed on the site. This is expressed as a percentage of new building standard (%NBS). The loadings are in accordance with the current earthquake loading standard NZS1170.5 [1].

A generally accepted classification of earthquake risk for existing buildings in terms of %NBS that has been proposed by the NZSEE 2006 [2] is presented in Figure 1 below.

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	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
Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)	Unacceptable	Unacceptable

Figure 1: NZSEE Risk Classifications Extracted from Table 2.2 of the NZSEE 2006 AISPBE Guidelines

Table 1 below compares the percentage NBS to the relative risk of the building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year). It is noted that the current seismic risk in Christchurch results in a 6% risk of exceedance in the next year.

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 Linwood Community Crèche is a single storey timber framed building located on Aldwins Road in Linwood. For the purposes of this report we refer to the direction parallel to Aldwins Road as the north to south direction, and the direction perpendicular to Aldwins Road as the east to west direction.

From archive drawings we have ascertained that the building was built in 1996, with structural renovations to the building in 1999 extending a section of the building with further renovations and an extension in 2003.

The building is clad with lightweight Nu-wall aluminium cladding around the majority of the building and with sections of Hardiflex and kwila cladding at the back. The building sits on a 100mm thick reinforced concrete slab foundation with the floor slab for the extension connected to the original slab through doweled reinforcing.

The building is approximately 13.6m wide in the north to south direction and approximately 20m long in the east to west direction. The roof apex is approximately 4.8m above ground level.

4.2 Gravity Load Resisting System

The roof structure is made up of a series of timber trusses at approximately 900mm centres spanning across the building in the north-south direction. The walls are timber framed with 100x50mm studs approximately 2.7m high and lined with GIB board. The slab is a 100mm thick mesh reinforced slab on grade tied into a perimeter slab thickening.

4.3 Seismic Load Resisting System

Seismic loads in both orthogonal directions are resisted by a series of timber walls braced with GIB plasterboard sheets.

In the main indoor play area the ceiling is formed from a suspended ceiling grid hung from the timber roof trusses. This ceiling does not form a diaphragm, which is required to transfer the seismic loads to the braced walls due to the large spacing of 10m between the braced walls. The original specification noted that a ceiling diaphragm was provided however one was not provided in the indoor play area.

In the main entrance area the spacing of the braced walls generally complies with NZS3604:2011 although renovations have reduced the capacity of an internal bracing line to less than that required by NZS3604.

5 Survey

The playcentre building currently has a green placard (not issued as part of this inspection and authorised by an engineer working for a company other than Opus International Consultants).

Copies of the following archive drawings were referred to as part of the assessment:

- A set of C. W. Hadlee architectural drawings and specification in relation to the building's original construction dated 1997.
- A set of C. W. Hadlee architectural drawings and specification in relation to the renovations and extension of a new play area dated 1999.
- A set of Royal Associates Ltd architectural drawings in relation to the extension of the staff room and veranda dated 2003.

Copies of the original bracing calculations have been included as part of the documentation set.

The drawings have been used to confirm the structural systems, investigate potential critical structural weaknesses (CSW) wherever possible and identify details which required particular attention.

6 Damage Assessment

The following damage has been noted:

6.1 Slab separation at staff room extension

There is some cracking to the slab at the interface between the new staff room extension and the original building. The door from the staff room outside jammed following the February earthquake event and has since been repaired. The movement of the slab foundation is limited and appears to be within acceptable limits.

6.2 Cracking to skylight

There was some minor cracking to the paint/linings at the corners where the roof trusses pass through the circular skylight.

7 General Observations

Overall the building has performed well under seismic conditions which would be expected for a modern single storey structure. The building has sustained little damage and continues to be fully operational.

Due to the non-intrusive nature of the original survey, many connection details could not be ascertained.

8 Detailed Seismic Assessment

8.1 Critical Structural Weaknesses

As outlined in the Critical Structural Weakness and Collapse Hazards draft briefing document, issued by the Structural Engineering Society (SESOC) on 7 May 2011, the term 'Critical Structural Weakness' (CSW) refers to a component of a building that could contribute to increased levels of damage or cause premature collapse of the building.

The following critical structural weaknesses have been identified:

- The spacing between the braced walls in the indoor play area is around 10m, which exceeds the maximum limit of 6m without a ceiling diaphragm. The lack of a diaphragm may result in increased levels of damage to the building but will not result in a collapse.

8.2 Detailed Seismic Assessment Methodology

As the building is a timber framed structure constructed in 1995 it has been considered appropriate to derive the seismic loadings from NZS3604:2011 as the building falls within the scope of this design standard.

The seismic design parameters based on current design requirements from NZS 3604:2011 and the NZBC clause B1 for this building are as follows:

- Site soil class D, clause 3.1.3 NZS 1170.5:2004
- Earthquake Zone 2, Figure 5.4 – Earthquake zones NZS 3604:2011
- Multiplication factor = 0.8, Table 5.8 NZS 3604:2011
- Importance Level 2 structure with a 50 year design life to NZS 1170.5:2004

8.3 Detailed Seismic Assessment Results

A summary of the structural performance of the building is shown in the following table. Note that the values given represent the worst performing elements in the building, as these effectively define the building's capacity. Other elements within the building may have significantly greater capacity when compared with the governing element.

Table 2: Summary of Seismic Performance

Structural Element/System	Failure mode and description of limiting criteria	Critical Structural Weakness and Collapse Hazard	% NBS based on calculated capacity
GIB board capacity along the building (east-west)	Capacity of GIB board braced walls along the building	No	73%
GIB board capacity across the building (north-south)	Capacity of GIB board braced walls across the building	No	77%
Diaphragm capacity	No diaphragm has been provided, but is required based on the spacing of the bracing lines	Yes (CSW only, with an increased level of damage)	40-60%

8.4 Discussion of Results

The lateral capacity of the building is provided by a series of GIB lined timber framed walls. The original bracing calculations for the building used NZS3604:1990 and assumed a seismic capacity requirement of 2 bracing units per meter square of floor area leading to a seismic demand of 450 bracing units (23kN) in each direction. In the current code NZS3604:2011 the seismic demand on the building has increased to 4.8 bracing units per square meter of floor area giving a requirement of 1296 (65kN) bracing units in each direction.

Although the seismic demand on the building has increased greatly the overall design demand has not increased significantly as wind loading was the critical load case for the original design

Renovations undertaken in the office/reception area have reduced the capacity of the bracing line between this area and the main corridor to less than the minimum capacity of an internal bracing line required in NZS 3604:2011. However the presence of the wall will provide some support for the roof diaphragm at this end of the structure. The lack of a ceiling diaphragm in the main play area means that it is difficult to transfer seismic loads to the braced wall at the far end of the building adjacent to the verandah. The ceiling in this area is a suspended ceiling hung from the roof trusses and therefore provides no bracing capacity. The seismic loads must therefore be resisted by the braced wall adjacent to the sleeping room, which is spaced 7m from the office/reception wall. The sleeping room also appears to be bounded by a suspended ceiling. Therefore although the walls generally have a capacity greater than 67% NBS there are limitations on how much load can be transferred to them by the top plates and diaphragms.

The building has a seismic capacity of around 40-60% NBS as governed by the load transfer to the braced walls and is therefore not classed as an earthquake prone building.

8.5 Limitations and Assumptions in Results

Our analysis and assessment is based on an assessment of the building in its undamaged state, although this building has not suffered significant structural damage. Therefore the current capacity of the building may be lower than that stated.

The results have been reported as a %NBS and the stated value is that obtained from our analysis and assessment. Despite the use of best national and international practice in this analysis and assessment, this value contains uncertainty due to the many assumptions and simplifications which are made during the assessment. These include:

- Simplifications made in the analysis, including boundary conditions such as foundation fixity;
- Assessments of material strengths based on limited drawings, specifications and site inspections;
- The normal variation in material properties which change from batch to batch;
- Approximations made in the assessment of the capacity of each element, especially when considering the post-yield behaviour.

9 Geotechnical Assessment

The geotechnical report is contained in Appendix C of this report. A summary of the report is as follows:

9.1 Discussion

Minor damage has occurred to the building at 136 Aldwins Road due to the Canterbury Earthquake Sequence following the 4 September 2010 earthquake.

No obvious evidence of surface rupture or lateral spreading due to the recent earthquakes was observed on the property or adjoining properties. While liquefaction has occurred in close proximity to the site, it appears the existing shallow foundations have performed adequately in recent earthquakes.

The existing building is supported on a reinforced concrete slab on grade, connected into a shallow reinforced concrete perimeter strip footing. The existing foundations have performed satisfactorily and do not appear to have sustained damage from cracking from differential settlement. The existing foundations are considered appropriate for the building with CCC acceptance of potential differential subsidence damage.

GNS Science indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the 4 September 2010 earthquake. Recent advice1 indicates there is an 18% probability of another Magnitude 6 or greater

[1] GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury-quakes/aftershocks/ updated on 3 February 2012.

earthquake occurring in the next 12 months in the Canterbury region. This event may cause liquefaction induced land damage at the site similar to that experienced, however it is dependent on the location of the earthquakes epicentre. This confirms that there is currently a significant risk of liquefaction and differential settlements occurring. It is expected that the probability of occurrence is likely to decrease with time following periods of reduced seismic activity.

9.2 Recommendations

a) Based on the building performance in recent earthquakes, the existing foundations should be acceptable in terms of future ultimate limit state (ULS) and serviceability limit state (SLS) loadings, although the CCC will have to accept the risk for potential differential settlement in the order of 0 to 50mm in a future seismic event;

b) If the CCC wish to further evaluate and quantify the liquefaction potential at this specific site, additional site testing comprising two CPT's and associated analysis would be required. Allowance should be made for predrilling of shallow gravels, if encountered, to complete CPT testing.

10 Remedial Options

Remedial options to increase the building capacity to at least 67% NBS would involve addressing the transfer of load to the braced walls in the main play area.'

11 Conclusions

(a) The building has a seismic capacity of around 40-60% NBS as governed by the lack of a ceiling diaphragm, which has been classed as a critical structural weakness.

(b) Strengthening works addressing the issue of a lack of a ceiling diaphragm would increase the buildings overall seismic capacity to 73% NBS

(c) Based on the building performance in recent earthquakes, the existing foundations should be acceptable in terms of future ultimate limit state (ULS) and serviceability limit state (SLS) loadings, although the CCC will have to accept the risk for potential differential settlement in the order of 0 to 50mm in a future seismic event;

(d) If the CCC wish to further evaluate and quantify the liquefaction potential at this specific site, additional site testing comprising two CPT's and associated analysis would be required. Allowance should be made for predrilling of shallow gravels, if encountered, to complete CPT testing.

12 Recommendations

(a) A conceptual strengthening works design be undertaken to provide adequate load paths to transfer seismic loads to the braced walls

13 Limitations

(a) This report is based on an inspection of the structure with a focus on the damage sustained from the 22 February 2011 Canterbury Earthquake and aftershocks only. Some non-structural damage is mentioned but this is not intended to be a comprehensive list of non-structural items.

(b) Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at the time.

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

Appendix A – Photographs

Photo 1 – Western perimeter wall as seen from Aldwins Road

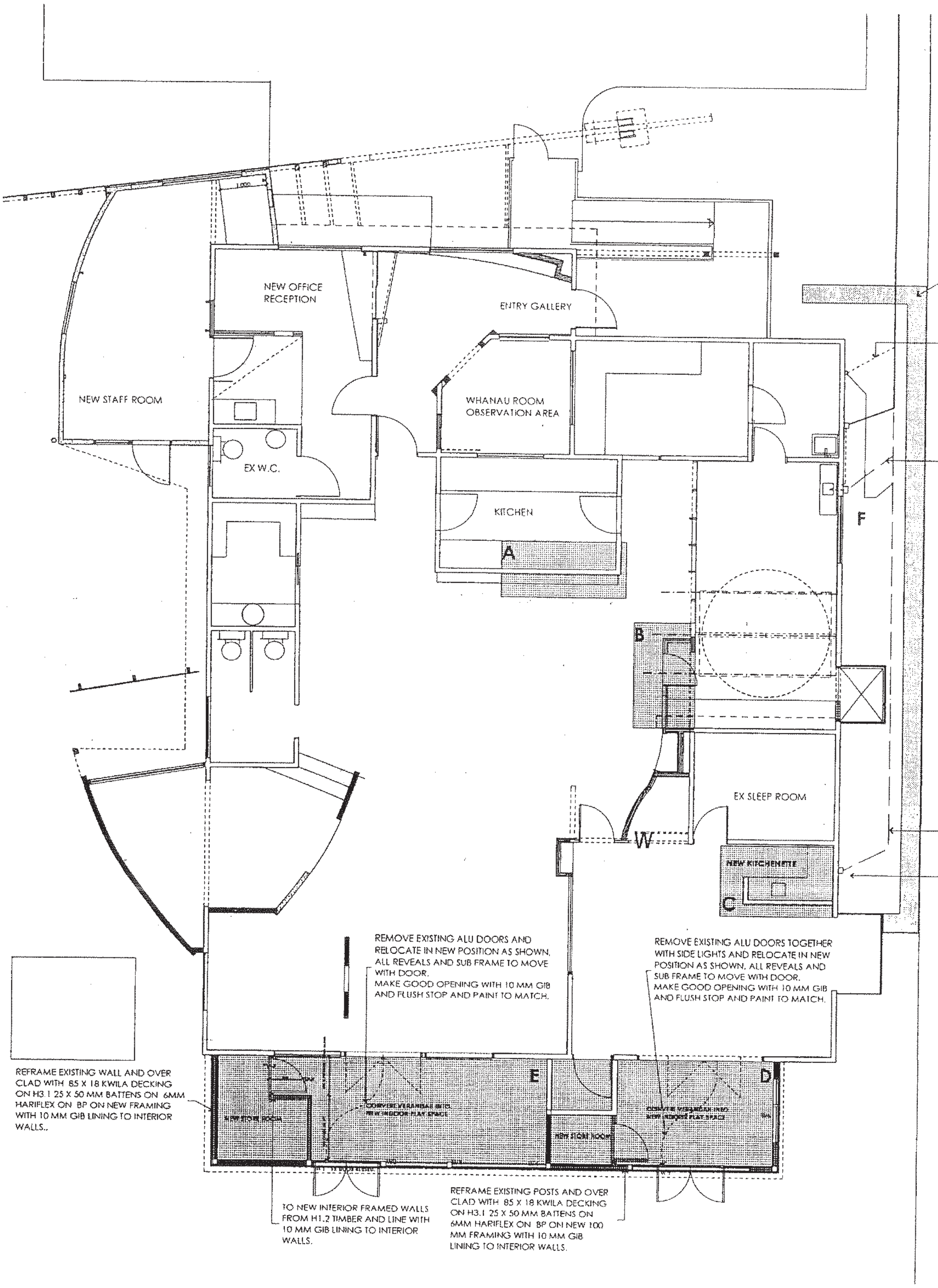
Photo 2 – Eastern perimeter wall

Photo 3 – Northern perimeter wall

Photo 4 - Cracking to GIB lining in the staff room where the slab extension has moved

Photo 5 – Paint cracking in the circular skylight

Appendix B – Floor Plan



TO LINE SHOWN PROVIDE AN APPROVED FILTER CLOTH 300mM ALONG GROUND AND 200mm MIN UP THE FENCE TOGETHER WITH PEA STRAW BALES IN A CONTINUOS LINE TO ENSURE NO SEDIMENT RUNOFF DURING CONSTRUCTION. DURING CONSTRUCTION AND ONCE ROOFS ARE ON, THE CONTRACTORS ARE TO ENSURE ALL CATCHMENT WATER IS VETICULATED WITHIN THE SITE TO AVOID MIGRATION ACROSS THE BOUNDARY.

EXISTING T.V RECONNECTED TO MAIN LINE BEYOND EXISTING & NEW

NEW GT & CONNECTION TO MAIN LINE 100mm PVC

SCOPE OF WORK

- **A** ALU AND GLASS SCREEN TO PROTECT CHILDREN FROM THE KITCHEN BENCH
- **B** NEW ALU AND GLASS SCREEN TOGETHER WITH NEW ALU DOOR AND OVER HEAD GLASS.
- **C** NEW KITCHENETTE COMPLETE WITH FRIG, MICROWAVE, AND SINK BENCH. DISCHARGE TO NEW G.T.
- **D** CONVERT EXISTING PORCH, INTO INTERIOR SPACE. RELOCATE EX ALU DOORS AND SIDE LIGHTS TO EXTERIOR FACE, DIG UP EX CONC SLAB, AND RENEW WITH NEW SLAB, DPC, INSULATION, AND NEW GLAZING
- **E** AS FOR - D ABOVE
- **F** EXTEND EXIST SEWER AND INSTALL 2 NEW G.T'S AND RECONNECT TERMINAL VENT.

NEW 100mm PVC SECTION
MIN 1:120

NEW G.T

SET 04

DRAWING TITLE: FLOOR PLAN	CREATION - DATE: 02/05/2006 PLOT - DATE: 4/12/2007
SCALE: A4 A3 1:100	DRAWING NUMBER: A-02

PROPOSED ALTERATIONS STAGE 4
For
NEW BEGININGS PRESCHOOL
136 ALDWINS ROAD
LINWOOD

raà
ROYAL ASSOCIATES LIMITED
REGISTERED ARCHITECTS
atelier - 62 AVONSIDE DRIVE, CHRISTCHURCH, NEW ZEALAND
TELEPHONE: 064 3 3799 645 FACSMILIE: 064 3 3799 65[illegible]
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Appendix C – Geotechnical Appraisal

17 February 2012

Lindsay Fleming
Christchurch City Council
PO Box 237
CHRISTCHURCH 8140

6-QUCCC.60/005SC

Dear Lindsay

Geotechnical Desktop Study – Linwood Community Crèche (New Beginnings Pre-School Inc.)

1. Introduction

This report summarises the findings of a geotechnical desktop study and site walkover completed by Opus International Consultants (Opus) for the Christchurch City Council at the above property on 26 January 2012. The Geotechnical desk study follows the Canterbury Earthquake Sequence initiated by the 4 September 2010 earthquake.

The purpose of the geotechnical study is to assess the current ground conditions and the potential geotechnical hazards that may be present at the site, and determine whether further subsurface geotechnical investigations are necessary.

It is our understanding this is the first inspection by a Geotechnical Engineer of this property following the Canterbury Earthquake Sequence. Rapid structural inspections have been undertaken by Opus on 9 March 2011 and 17 June 2011.

2. Desktop Study

2.1 Site Description

The Linwood Community Crèche is located east of the Christchurch Central Business District, approximately 250m southwest of the Linwood Avenue/Aldwins Road intersection. The site is relatively flat.

The original building was constructed in 1997 while alterations completed in 1999, 2003 and 2007 have been undertaken. The building is a single storey structure with timber framed walls clad in various light materials.

2.2 Structural Drawings

We have received extracts from building consent drawings prepared by C W Hadlee Architects dated 1999 and Royal Associates Limited dated May 4 2004 (refer Appendix A) which detail the foundations to the existing building and subsequent additions.

The drawings indicate the existing foundations comprise a 100mm thick 17.5 MPa concrete slab on grade reinforced with 665 or 668 mesh, connected into a 450mm deep by 165mm wide concrete perimeter strip footing with 2 D12 lateral reinforcement rods tied into the concrete slab by R10 ties at 600 centres.

No geotechnical report or record of a ground conditions assessment associated with the construction of the original building or additions have been provided by the Christchurch City Council.

2.4 Regional Geology

The published geological map of the area, (Geology of the Christchurch Urban Area 1:25,000, Brown and Weeber, 1992) indicates the site is located at the boundary between two surficial geological soil types, one being dominantly sand of fixed and semi-fixed dunes and beaches and the other dominantly alluvial sand and silt overbank deposits belonging to the Yaldhurst member of the Springston Formation.

A groundwater table depth of approximately 1m has been shown on the published map by Brown and Weeber (1992).

2.5 Expected Ground Conditions

A review of the Environmental Canterbury (Ecan) Wells database showed three wells located within approximately 190 m of the property (refer to Site Location Plan and Appendix B). Material logs available from two of these wells have been used to infer the ground conditions at the site as shown in table 1 below.

Stratigraphy	Thickness	Depth Encountered from bgl
TOPSOIL	0.5m	0
SILT	0.5m	0.5m
SAND with interbedded SILT layers	1.0-8.1m	1.0m
sandy GRAVEL	10.7m	9.1m
clayey SAND	7.0m	19.8m
Sandy GRAVEL (Riccarton Formation)	-	32.3m

Table 1 Inferred Ground Conditions

Borehole log M35/16559 recorded a ground water level of 1.1m below the ground.

Subsurface investigations have been completed by Tonkin and Taylor on behalf of the Earthquake Commission around Christchurch. CPT-LWD-28 (refer Appendix C), completed in Linwood Park, approximately 90m southeast of the site, indicated the presence of a suspected dense sand, shallow gravel layer or an obstruction at approximately 4.2m below ground level.

2.6 Liquefaction Hazard

Examination of post-earthquake aerial photos did not identify any evidence of significant quantities of liquefied soils ejected at the ground surface after the Magnitude 7.1 September 2010, Magnitude 6.3 February 2011 event or recent aftershocks. It appears soils ejected resultant from liquefaction occurred in Aldwins Road, but little to no material was ejected at the property.

The 2004 Environment Canterbury Solid Facts Liquefaction Study indicates the site is in an area designated as 'moderate liquefaction ground damage potential'. According to this study, based on a low groundwater table, ground damage is expected to be moderate and may be affected by 100-300mm of ground subsidence.

The Christchurch Earthquake Recovery Authority (CERA) last updated 11 December, 2011 has classified 136 Aldwins Road and surrounding residential properties as Green Zone, indicating repair and rebuilding process can begin. The maps that were released by the Department of Building and Housing (DBH) on 9 February 2012 indicate that the area surrounding the site is classified as Technical Category 2 (yellow), which indicates that minor to moderate land damage from liquefaction is possible in future significant earthquakes.

3. Site Walkover Inspection

A walkover inspection of the interior of the building and surrounding land was carried out by Mark Broughton, Opus Geotechnical Engineer on 26 January 2012. The following observations were made (refer to the Walkover Inspection Plan and Site Photographs attached to this report):

- 50mm undulations in the asphalt footpath due to liquefaction, observed 20m northeast of property on Aldwins Road near fire hydrant (refer Photograph 2);
- Evidence of ejected sand material due to liquefaction at the kerb on Aldwins Road;
- 10mm depression in asphalt carpark surface;
- hairline cracks in concrete encasement to slotted drain around the perimeter of the building. Possibly due to seismic shaking (Refer Photograph 3);
- settlement of concrete tile/paver in rear of section by up to 20mm;
- 3mm crack in concrete path;
- numerous cracks in gib and gib linings in interior of the dwelling, predominantly confined to the northern part of the building;
- a number of windows and doors had been realigned to open and close properly. Largely confined to the northern part of the building;

4. Discussion

Minor damage has occurred to the building at 136 Aldwins Road due to the Canterbury Earthquake Sequence following the 4 September 2010 earthquake.

No obvious evidence of surface rupture or lateral spreading due to the recent earthquakes was observed on the property or adjoining properties.

While liquefaction has occurred in close proximity to the site, it appears the existing shallow foundations have performed adequately in recent earthquakes.

The existing building is supported on a reinforced concrete slab on grade, connected into a shallow reinforced concrete perimeter strip footing. The existing foundations have performed satisfactorily and do not appear to have sustained damage from cracking from differential settlement. The existing foundations are considered appropriate for the building with CCC acceptance of potential differential subsidence damage.

GNS Science indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the 4 September 2010 earthquake. Recent advice[1] indicates there is an 18% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. This event may cause liquefaction induced land damage at the site similar to that experienced, however it is dependent on the location of the earthquakes epicentre. This confirms that there is currently a significant risk of liquefaction and differential settlements occurring. It is expected that the probability of occurrence is likely to decrease with time following periods of reduced seismic activity

5. Recommendations

- Based on the building performance in recent earthquakes, the existing foundations should be acceptable in terms of future ultimate limit state (ULS) and serviceability limit state (SLS) loadings, although CCC will have to accept the risk for potential differential settlement in the order of 0 to 50mm in a future seismic event;

- If Christchurch City Council wish to further evaluate and quantify the liquefaction potential at this specific site, additional site testing comprising x2 CPT's and associated analysis would be required. Allowance should be made for predrilling of shallow gravels, if encountered, to complete CPT testing.

6. Limitation

This report has been prepared solely for the benefit of Christchurch City Council as our client with respect to the brief. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

Prepared By:

pp [signature]

Mark Broughton
Geotechnical Engineer

Reviewed By:

[signature]

Graham Brown
Senior Geotechnical Engineer

<u>Figures:</u>
Site Photographs
Site Location Plan
Walkover Inspection Plans

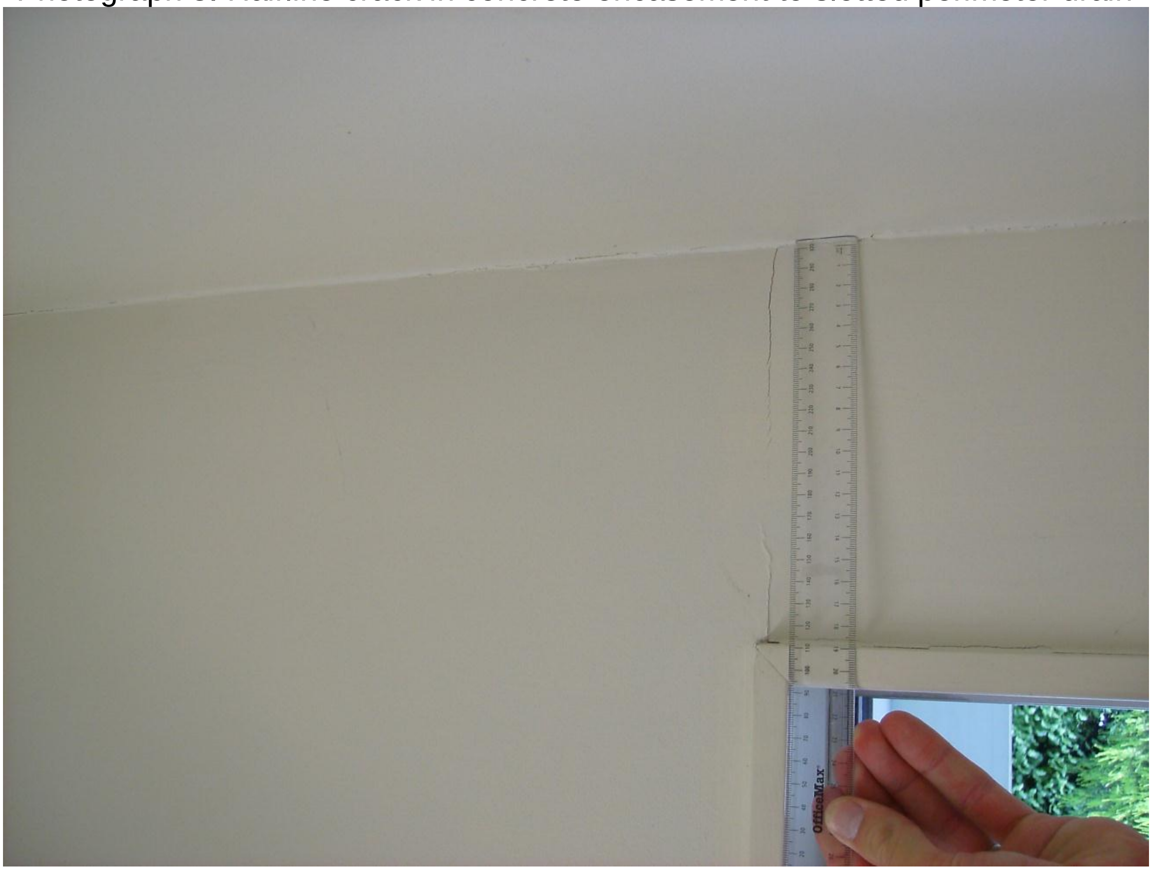
<u>Appendices:</u>
Appendix A: Building Consent Drawings
Appendix B: Environment Canterbury Borehole Logs
Appendix C: CPT-LWD-28 Report

[1] GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury-quakes/aftershocks/ updated on 3 February 2012.

Photograph 1. Northern Elevation (Main entrance to building)

Photograph 2. 50mm undulations in asphalt footpath adjacent site on Aldwins Road

Photograph 3. Hairline crack in concrete encasement to slotted perimeter drain



Photograph 4. Typical cracking in Gib above door frame in northern part of building

SOURCE: canterburyrecovery.projectorbit.com (Accessed on 26/01/12)

BH ref	Ecan ref
1	M35/2111
2	M35/16559
3	M35/14475

Ref	CPT Ref
4	CPT-LWD-28

OPUS
Opus International Consultants Ltd
Christchurch Office
20 Moorhouse Ave
PO Box 1482
Christchurch, New Zealand
Tel: +64 3 363 5400 Fax: +64 3 365 7857

Project: Linwood Community Creche
Geotechnical Desktop Study

Project No.: 6-QUCCC.60

Client: Christchurch City Council

Site Location Plan

Drawn: Mark Broughton
Geotechnical Engineer

Date: 26/01/2012

Opus International Consultants Ltd
Christchurch Office
20 Moorhouse Ave
PO Box 1482
Christchurch, New Zealand
Tel: +64 3 363 5400 Fax: +64 3 365 7857

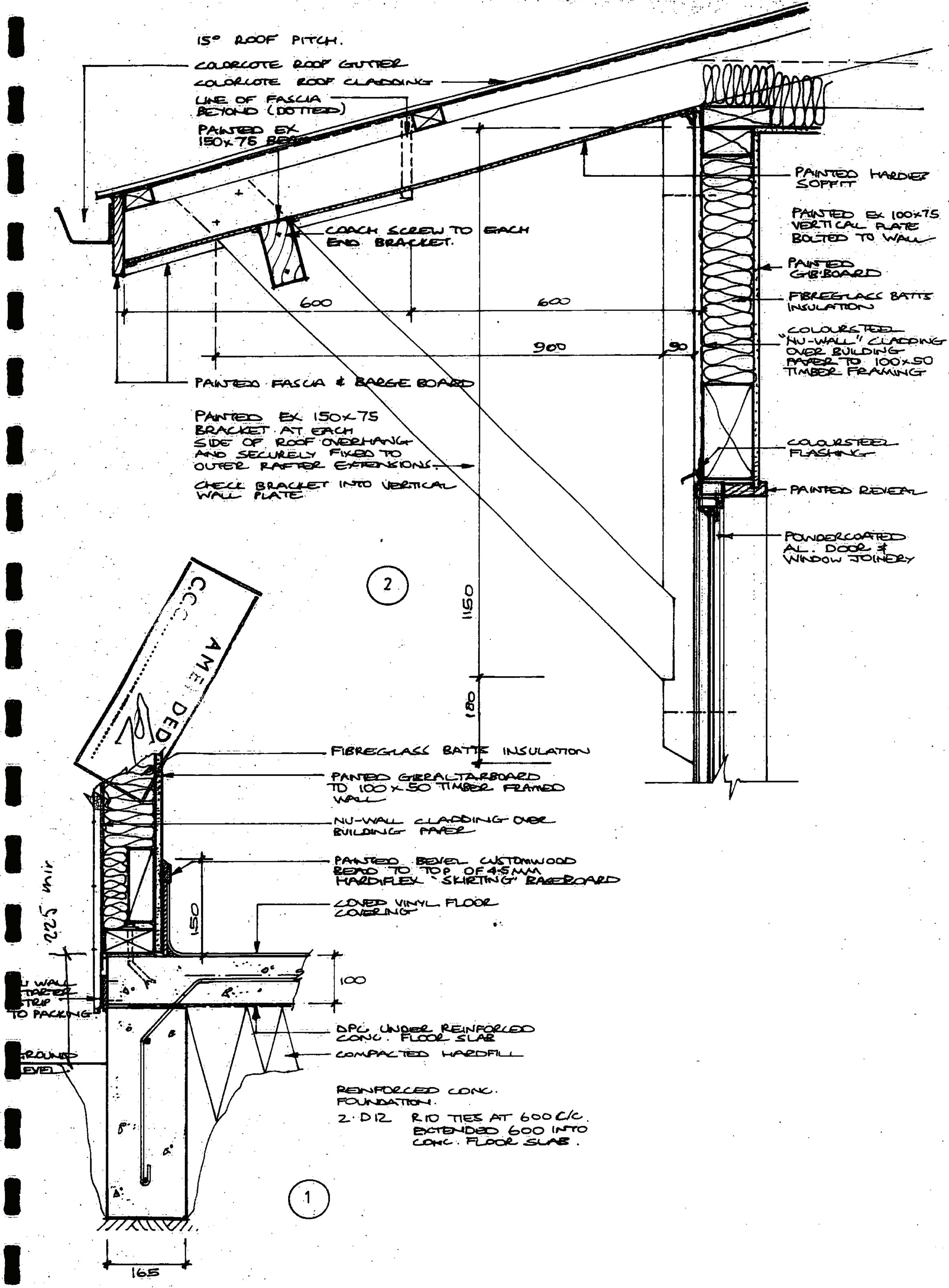
Project: Linwood Community Creche Geotechnical Desktop Study
Project No.: 6-QUCCC.60
Client: Christchurch City Council

Walkover Inspection Plan

Completed by: Mark Broughton on 26/01/2012, Geotechnical Engineer
Date Drawn: 30/01/2012

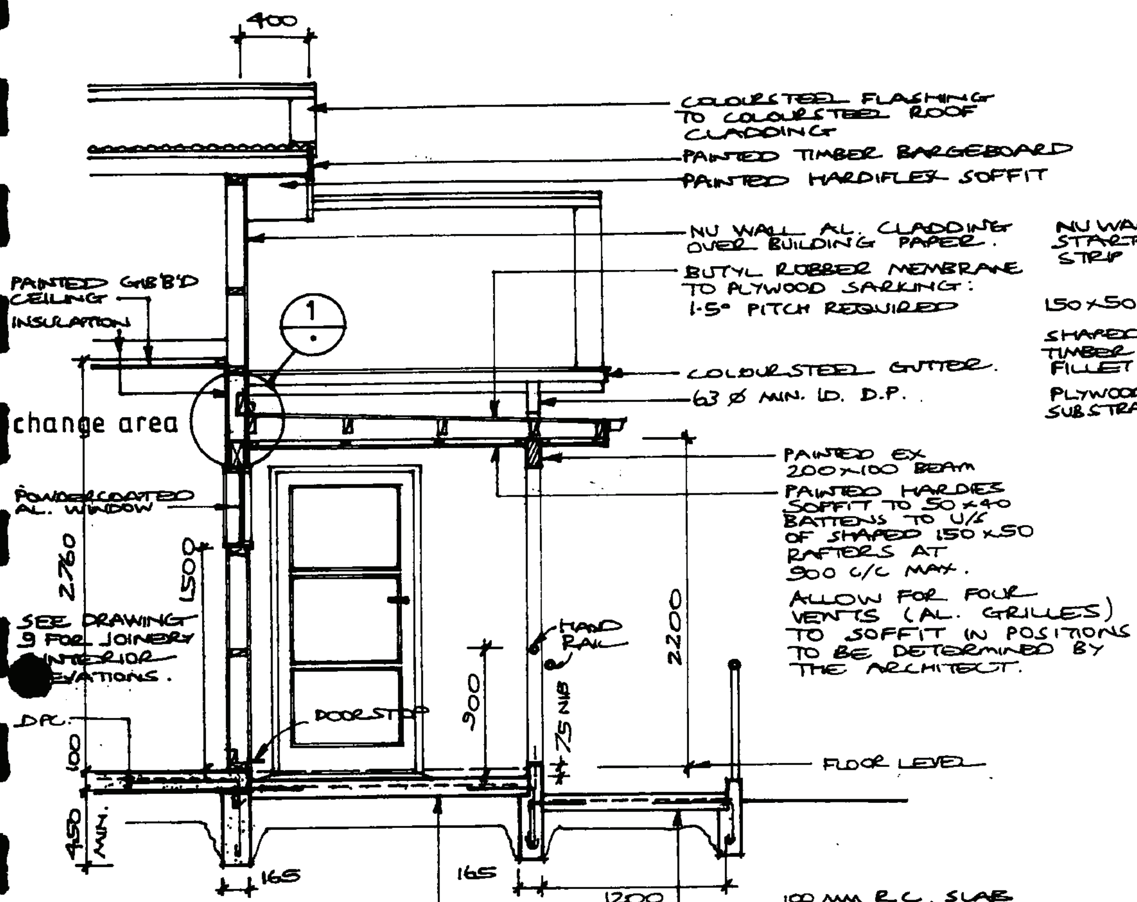
Appendix A:

Building Consent Drawings

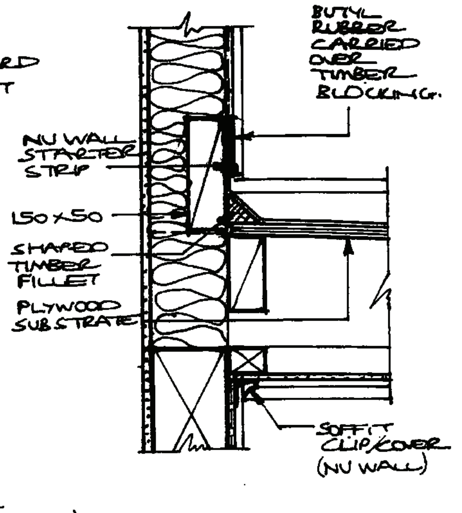


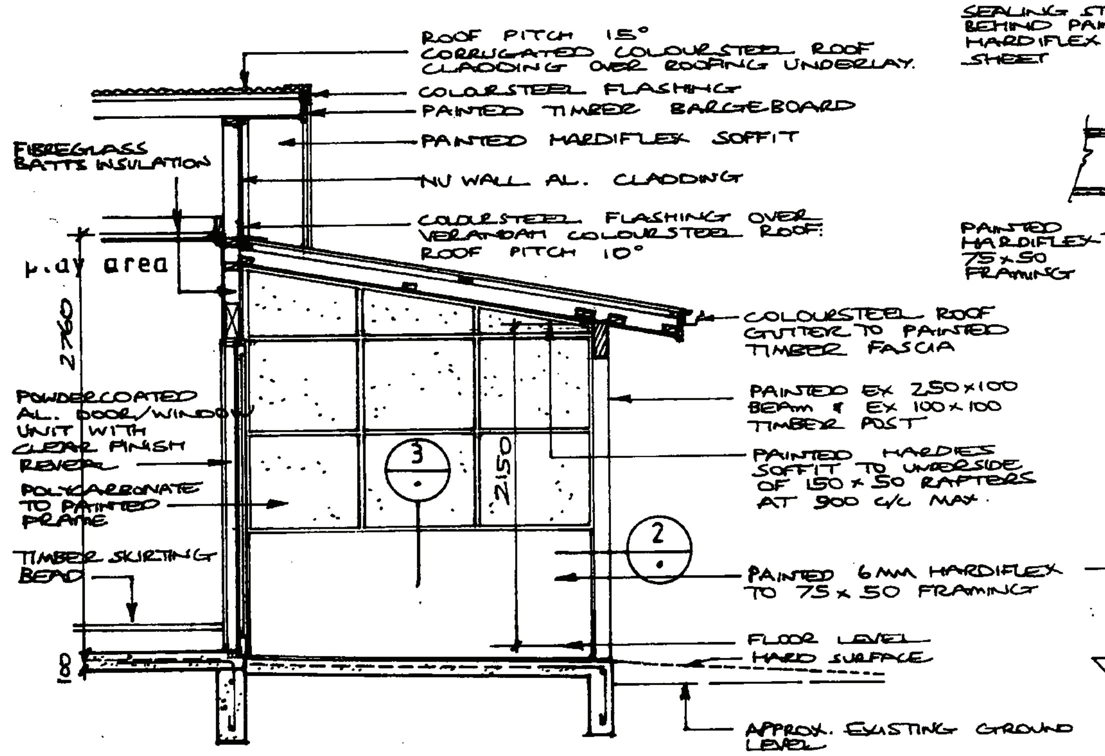
DETAILS 12

INWOOD CRECHE 7·7·96 1:10 9515

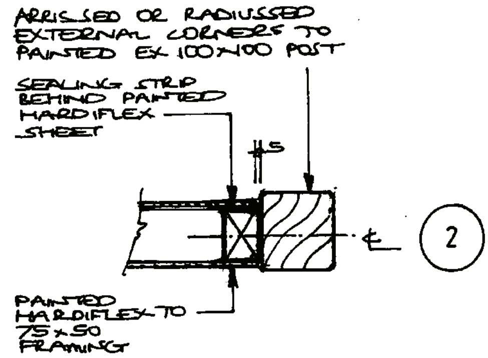


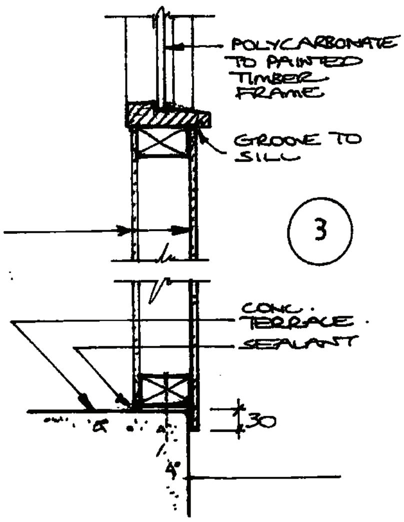
SECTION 3
1:50



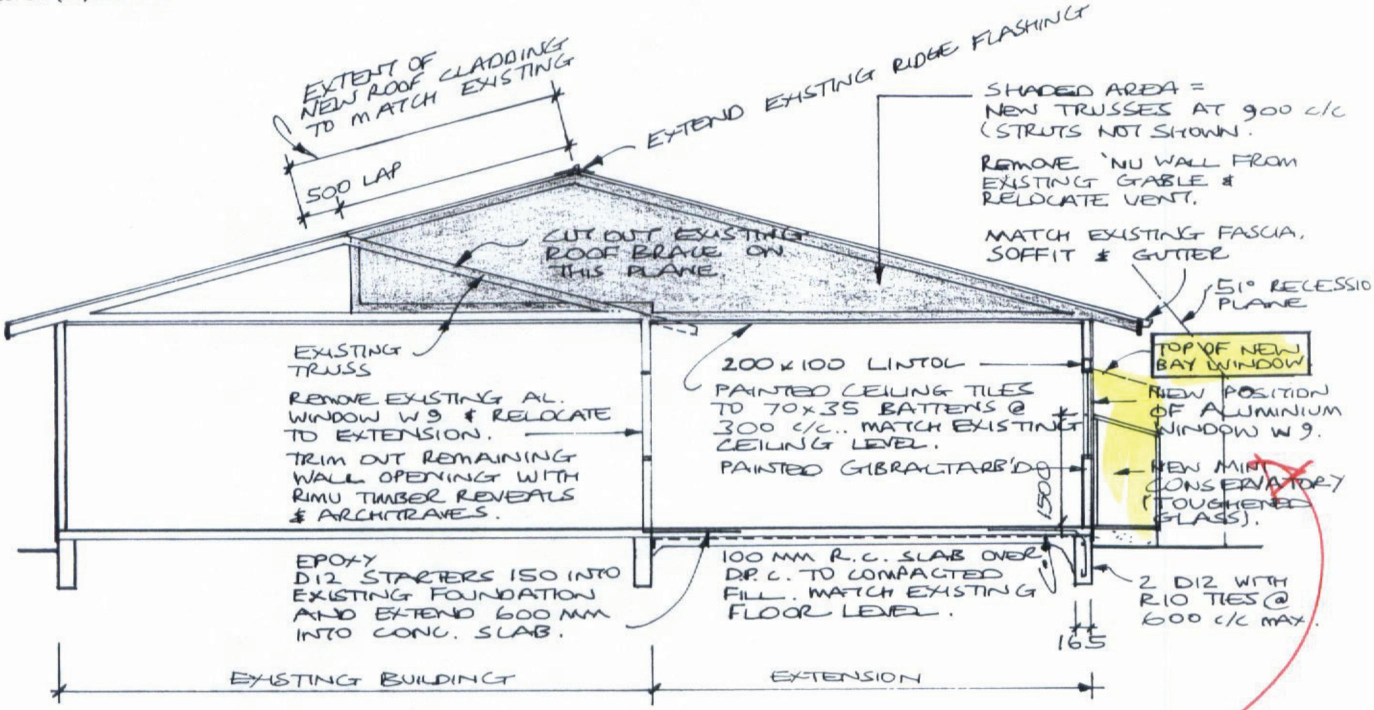


SECTION 4
1:50



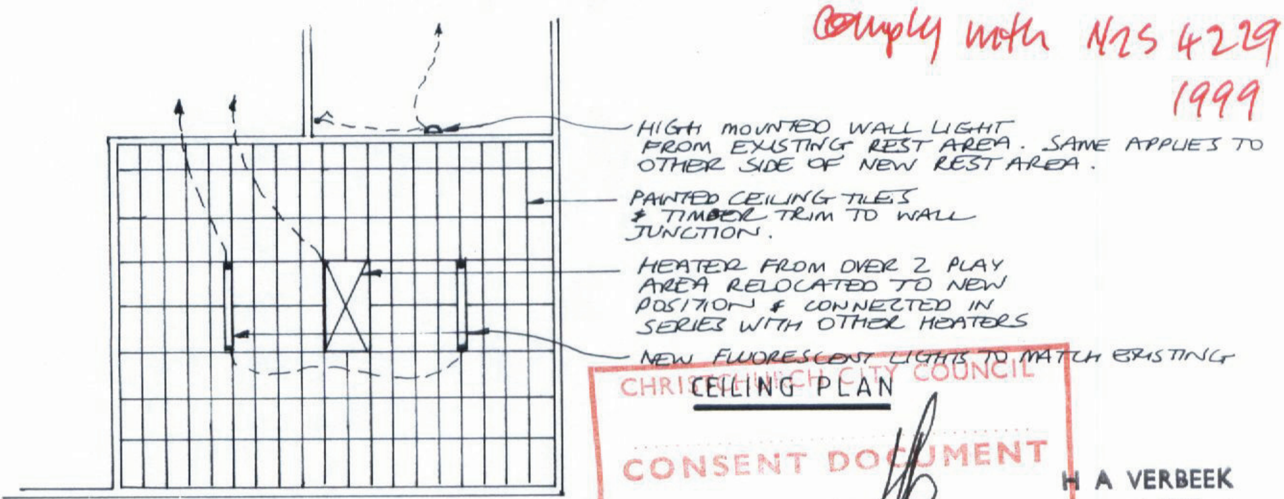


C.W. Hadlee, Architect
3 Tillman Avenue, CHCH 5
Tel/Fax: (03) 352-7149



CROSS - SECTION

Comply with NZS 4229 1999



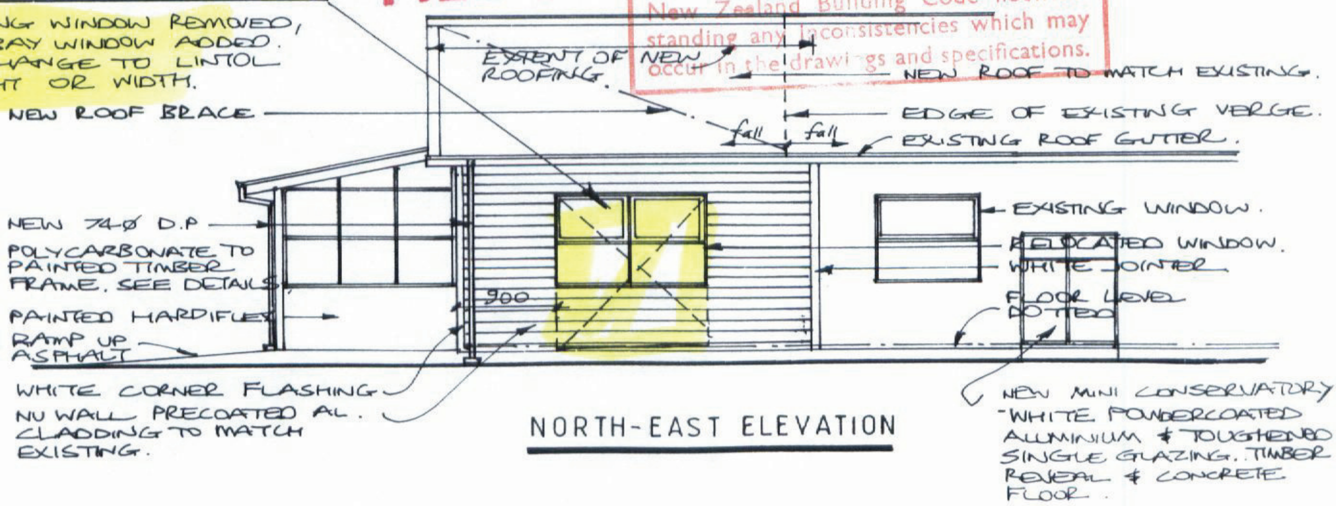
CEILING PLAN

CHRISTCHURCH CITY COUNCIL
CONSENT DOCUMENT
18 DEC 1999
H A VERBEEK
Consent Officer
All building work shall comply with the New Zealand Building Code notwithstanding any inconsistencies which may occur in the drawings and specifications.

FILE COPY

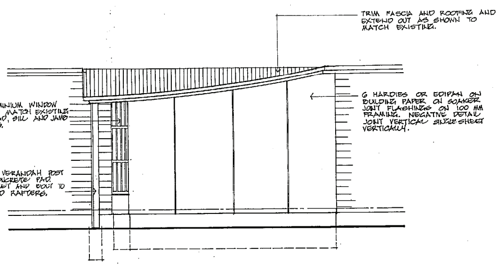
DRAWING MODIFIED 3·12·99

EXISTING WINDOW REMOVED, NEW BAY WINDOW ADDED. NO CHANGE TO LINTOL HEIGHT OR WIDTH.



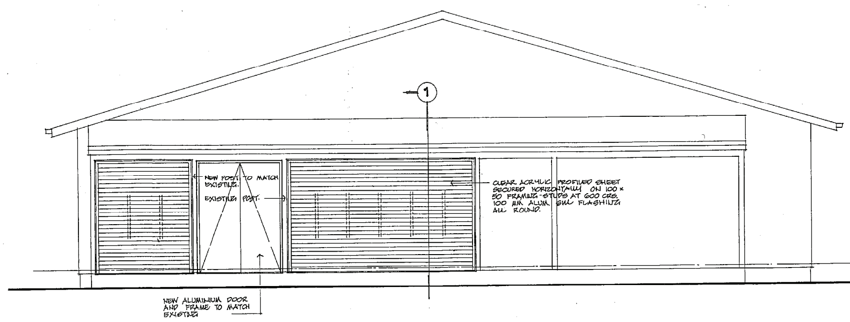
NORTH-EAST ELEVATION

PROPOSED ALTERATIONS TO LINWOOD CRECHE : ALDWINS ROAD 1:100, 23·6·99 9830 4



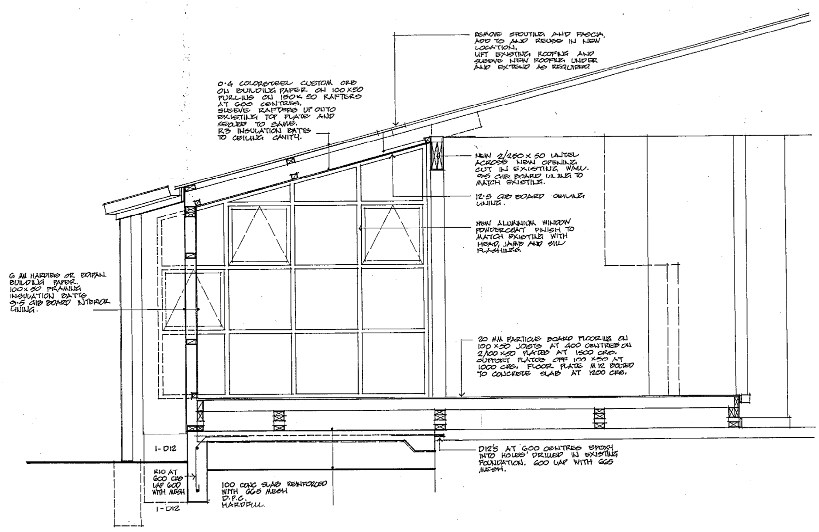
PART WEST ELEVATION
SHOWING PASSIVE PLAY AREA PROJECTION

SCALE : 1 TO 50



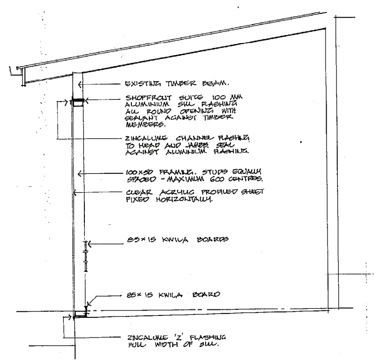
SOUTH ELEVATION
SHOWING PART CLOSING-IN OF VERANDAH

SCALE : 1 TO 50



SECTION THROUGH PASSIVE PLAY AREA

SCALE : 1 TO 25



SECTION AT (1)

SCALE : 1 TO 25

CHRISTCHURCH CITY COUNCIL
P.I.M. APPLICATION
Rec'd 9 - AUG 2004
Linwood Service Centre
PROJECT No. 10048081

LINWOOD COMMUNITY CRECHE
NEW BEGINNINGS
CHRISTCHURCH

TITLE
ELEVATIONS
SECTIONS
DETAILS

Stage 2.

DATE
MARCH 2004

SCALE
A2 1:50 1:25

SHEET No.
A-3.00

ROYAL ASSOCIATES LIMITED
REGISTERED ARCHITECTS

THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS ON THE SITE BEFORE COMMENCING ANY WORK

Appendix B:

Environment Canterbury Borehole Logs

Borelog for well M35/14475

Gridref: M35:83416-41281 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 4.2 +MSD
Well name : CCC BorelogID 3317
Drill Method : Not Recorded
Drill Depth : -2.29m Drill Date :

Environment Canterbury Regional Council

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
-0.2, -0.4, -0.6, -0.8		-0.91m	clay	
-1, -1.2, -1.4, -1.6, -1.8		-1.98m	wet sand	
-2, -2.2		-2.29m	silt	

Borelog for well M35/16559

Gridref: M35:83499-41318 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 3 +MSD
Well name : CCC BorelogID 6112
Drill Method : Not Recorded
Drill Depth : -1.8m Drill Date : 22/05/2006

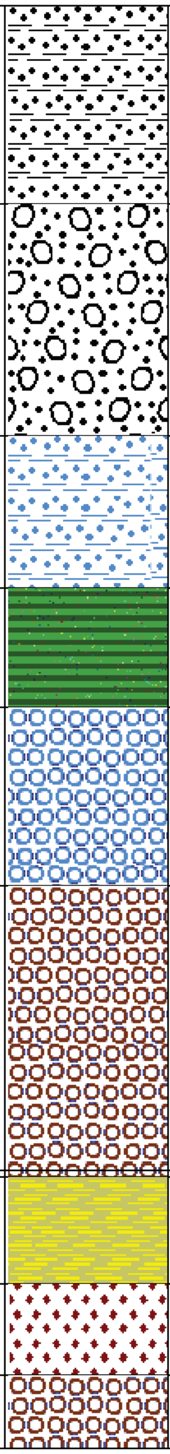
Environment Canterbury Regional Council

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
-0.2, -0.4		-0.50m	topsoil	
-0.6, -0.8, -1		-1.00m	grey / brown mottled silt	
-1.2, -1.4, -1.6		-1.80m	grey saturated sand	

Borelog for well M35/2111

Gridref: M35:836-414 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 3.1 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -66.4m Drill Date : 8/12/1944

Environment Canterbury Regional Council



Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	-9.10m	Sand & clay	sp?
	- 19.8m	Sand & gravel	sp?
	- 26.8m	Blue sand & clay	ch
	- 32.3m	Blue clay & peat	ch
	- 40.5m	Blue shingle	ri
	- 53.6m	Brown shingle	ri
	- 53.9m	Blue sand	br
	- 58.8m	Yellow clay	br
	- 63.0m	Brown sand	br
	- 66.4m	Brown shingle	li-1

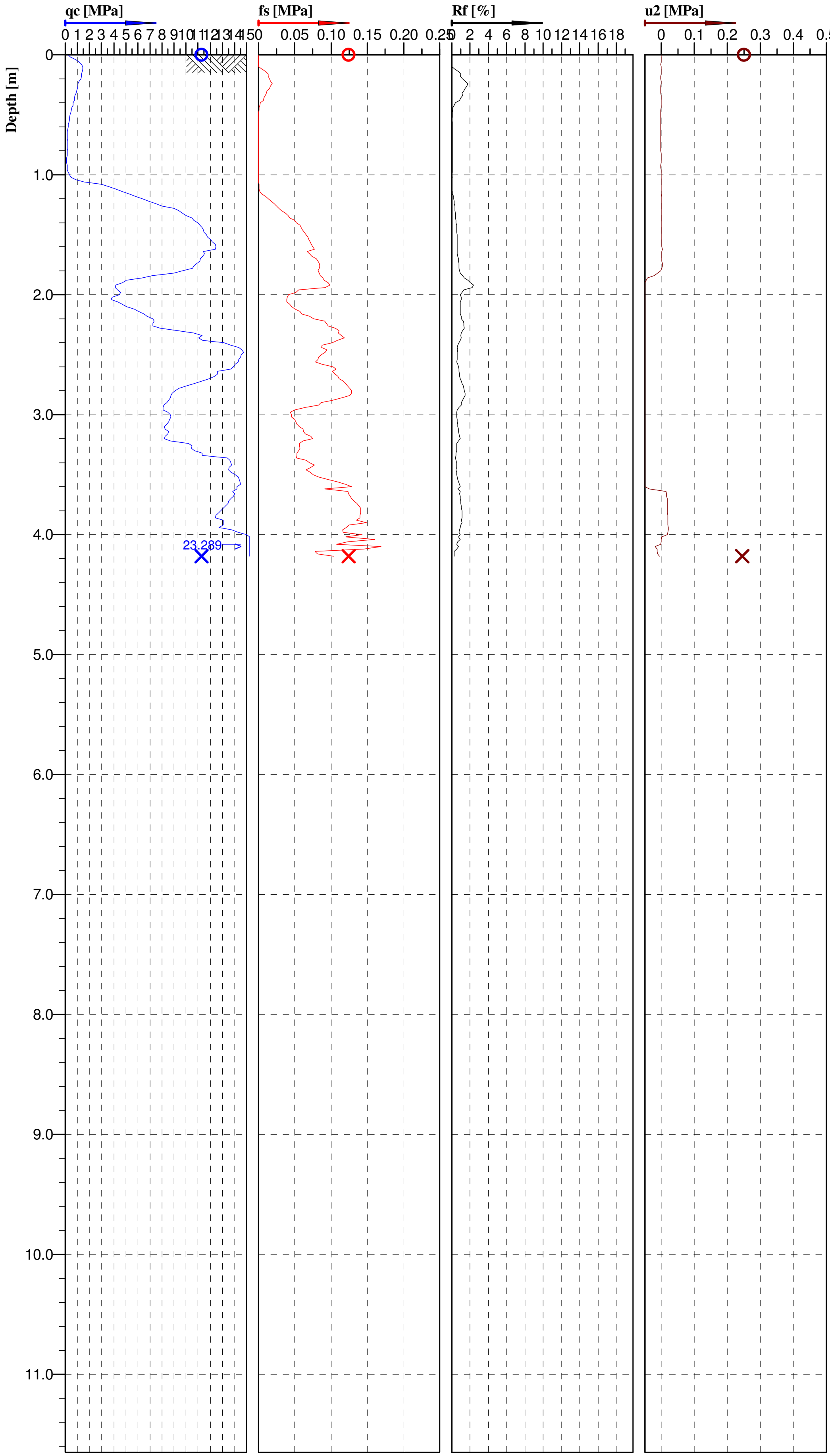
Scale(m): -10, -20, -30, -40, -50, -60

Appendix C:

CPT-LWD-28 Report

Classification by Robertson 1986

- Sandy silt to clayey silt (6)
- Sensitive fine grained (1)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)

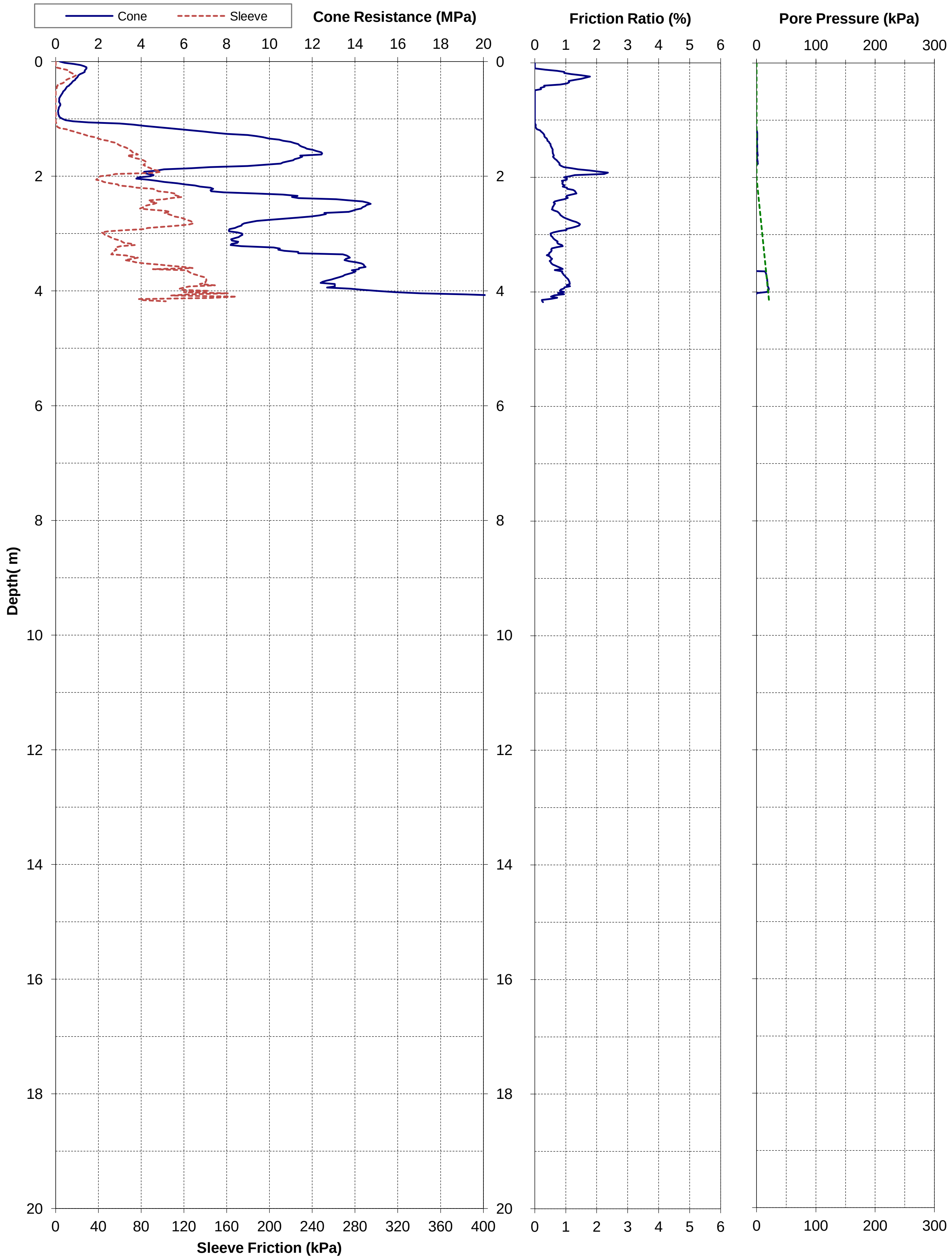


Cone No: 100KN 4341
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: LINWOOD	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: CPT-LWD-28
Project ID:	Client: TONKIN & TAYLOR LTD	Date: 19/05/2011	Scale: 1 : 50
Project: EQC SITES		Page: 1/1	Fig:
		File: CPT-LWD-28.CPT	

Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			**Page:**	1 of 1
Test Date:	19-May-2011	**Location:**	Linwood	**Operator:**	Geotech
Pre-Drill:	1.2m	**Assumed GWL:**	2mBGL	**Located By:**	Survey GPS
Position:	2483547.1mE	5741248.6mN	2.73mRL	**Coord. System:**	NZMG & MSL
Other Tests:				**Comments:**	

CPT-LWD-28



Appendix D – CERA DEE Spreadsheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Linwood Community Creche	Reviewer:	Alistair Boyce
	Unit / No: / Street	CPEng No:	209860
Building Address:	136 Aldwins Road	Company:	Opus International Consultants
Legal Description:		Company project number:	6-QUCCC.60
		Company phone number:	03 363 5400
	Degrees / Min / Sec		
GPS south:		Date of submission:	3-Sep-12
GPS east:		Inspection Date:	19/01/2012
		Revision:	Final
Building Unique Identifier (CCC):	BU 0836-002 EQ2	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	0
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):	5.00

Building

No. of storeys above ground:	1 (single storey = 1)	Ground floor elevation (Absolute) (m):	
Ground floor split?	no	Ground floor elevation above ground (m):	0.10
Storeys below ground	0		
Foundation type:	isolated pads, no tie beams	if Foundation type is other, describe:	
Building height (m):	4.80	height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	275		
Age of Building (years):	17	Date of design:	1992-2004
Strengthening present?	no	If so, when (year)?	
		And what load level (%g)?	
Use (ground floor):	educational	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 truss	truss depth, purlin type and cladding	2m high timber trusses and lightweight steel roof cladding
Floors:	concrete flat slab	slab thickness (mm)	100
Beams:	timber	type	
Columns:	timber	typical dimensions (mm x mm)	
Walls:			

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	lightweight timber framed walls	note typical wall length (m)	13
Ductility assumed, μ:	3.00		
Period along:	0.40 (0.00)	estimate or calculation?	estimated
Total deflection (ULS) (mm):		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):		estimate or calculation?	estimated
Lateral system across:	lightweight timber framed walls	note typical wall length (m)	20
Ductility assumed, μ:	3.00		
Period across:	0.40 (0.00)	estimate or calculation?	estimated
Total deflection (ULS) (mm):		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):		estimate or calculation?	estimated

Separations: (leave blank if not relevant)

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

Non-structural elements

Stairs:			
Wall cladding:	profiled metal	describe	Lightweight
Roof Cladding:	Metal	describe	Lightweight
Glazing:	aluminium frames		
Ceilings:	light tiles		
Services(list):			

Available documentation

Architectural	partial	original designer name/date	
Structural	none	original designer name/date	
Mechanical	none	original designer name/date	
Electrical	none	original designer name/date	
Geotech report	none	original designer name/date	

Damage

Site: (refer DEE Table 4-2)

Site performance:		Describe damage:	
Settlement:	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:	45%	Describe how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:	48%		
	Describe (summary):			
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	no	Describe:	

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

Recommendations

	Level of repair/strengthening required:	minor structural	Describe:	
	Building Consent required:	yes	Describe:	
	Interim occupancy recommendations:	full occupancy	Describe:	
Along	Assessed %NBS before:	73% (##### %NBS from IEP below)	If IEP not used, please detail assessment methodology:	Quantitative
	Assessed %NBS after:	40%		
Across	Assessed %NBS before:	77% (##### %NBS from IEP below)		
	Assessed %NBS after:	40%		

OPUS