Bexley Park BMX Track Toilets

PRK 1385 BLDG 002 EQ2

Detailed Engineering Evaluation

Quantitative Report

Christchurch City Council

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Bexley Park BMX Track Toilets

Detailed Engineering Evaluation Quantitative Report

Prepared by

Michael Cullum
Graduate Structural Engineer

Reviewed by

Dave Dekker
Principal Structural Engineer
MIPENZ, CPEng 1003026

Approved by

Will Parker
Principal Structural & Civil Engineer

Opus International Consultants Ltd
Hamilton Office
Princes Street
Private Bag 3057, Waikato Mail Centre,
Hamilton 3240
New Zealand

Telephone: +64 7 838 9344
Facsimile: +64 7 838 9324

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Detailed Engineering Evaluation
Quantitative Report - SUMMARY
Final

Bexley Park, Christchurch

Background
This is a summary of the quantitative report for the toilet building at the BMX track in Bexley Park. The summary is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group, visual inspections and measurements taken on 17 June 2012, and calculations.

Indicative Structure Strength
Based on the information available, and from undertaking a quantitative assessment, the structure's original capacity has been assessed to be greater than 75%NBS along and 51%NBS across the structure, and therefore is a moderate earthquake risk.

Foundations
The building foundations have failed due to liquefaction induced differential settlement.

Recommendations

a) The building and grey water collection box could be re-levelled, though this does not address the risk of differential settlement recurring in future seismic events;

   The access ramp could be partially demolished and reconstructed to suit the new building level.

   The building should also be strengthened to at least 67%NBS.

b) Alternatively, the building could be demolished and replaced. New foundations could be a shallow raft type foundation (with provision to allow re-levelling if there is future liquefaction induced settlement), or deep to minimise liquefaction induced settlement.

The second option of demolishing and replacing may be preferable at this site as repair is likely to be difficult and expensive due to the ground conditions and building type.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the toilet building located at the BMX track in Bexley Park, Christchurch. This report was commissioned following the M6.3 Christchurch earthquake on 22 February 2011.

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

The seismic assessment and reporting have been undertaken based on the qualitative and quantitative procedure 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. It uses 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 owner’s 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 requires 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). CERA has adopted 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.

Any building with a capacity of less than 33% of New Building Standard (NBS) (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) 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).

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 (EPB)

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.

2.5 Institution of Professional Engineers New Zealand (IPENZ) Code of Ethics

One of the core ethical values of professional engineers in New Zealand is the protection of life and safeguarding of people. The IPENZ Code of Ethics requires that:

Members shall recognise the need to protect life and to safeguard people, and in their engineering activities shall act to address this need.

1.1 Giving priority to the safety and well-being of the community and having regard to this principle in assessing obligations to clients, employers and colleagues.

1.2 Ensuring that reasonable steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.

All recommendations on building occupancy and access must be made with these fundamental obligations in mind.

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
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)
Moderate Risk Building	C	Moderate	34 to 66	Acceptable legally. Improvement recommended
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)

Improvement of Structural Performance	
Legal Requirement	NZSEE Recommendation
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
	Not recommended. Acceptable only in exceptional circumstances
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.

Table 1: %NBS compared to relative risk of failure

Percentage of New Building Standard (%NBS)	Relative Risk (Approximate)
>100	<1 time
80-100	1-2 times
67-80	2-5 times
33-67	5-10 times
20-33	10-25 times
<20	>25 times

3.1 Minimum and Recommended Standards

Based on governing policy and recent observations, Opus makes the following general recommendations:

3.1.1 Occupancy

– The Canterbury Earthquake Order[1] in Council 16 September 2010, modified the meaning of 'dangerous building' to include buildings that were identified as being Earthquake Prone Buildings (EPB). Such a building would be issued with a Section 124 notice by the Territorial Authority, or CERA acting on their behalf, once they are

[1] This Order only applies to buildings within the Christchurch City, Selwyn District and Waimakariri District Councils authority

made aware of our assessment. Based on information received from CERA to date, this notice is likely to prohibit occupancy of the building (or parts of it) until its seismic capacity is improved to the point that it is no longer considered an EPB.

3.1.2 Cordoning

– Where there is an overhead falling hazard, or potential collapse hazard of the building, the areas of concern should be cordoned off in accordance with current CERA/Christchurch City Council guidelines.

3.1.3 Strengthening

– Industry guidelines (NZSEE 2006 [2]) strongly recommend that every effort be made to achieve improvement to at least 67%NBS. A strengthening solution to anything less than 67%NBS would not provide an adequate reduction to the level of risk.

– It should be noted that full compliance with the current building code requires building strength of 100%NBS.

3.1.4 Our Ethical Obligation

– In accordance with the IPENZ code of ethics, we have a duty of care to the public. This obligation requires us to identify and inform CERA of potentially dangerous buildings; this would include earthquake prone buildings.

4 Building Description

4.1 General

The building is a single-storey concrete masonry structure with a timber-framed roof, sitting on a concrete slab. We have no information on the foundation and have assumed that it is a slab on grade with edge thickenings beneath the perimeter masonry walls.

The building is situated on a flat section and is approximately 4m long in the north-south direction and 2.5m wide in the east-west direction. The apex of the roof is approximately 3.75m above the ground and the building has a wall height of approximately 2m.

The only wall openings are the doors on the west elevation.

We have no information on when the structure was constructed.

4.2 Gravity Load Resisting System

The roof is timber-framed and sarked with corrugated iron sheeting, supported on the external masonry walls.

4.3 Seismic Load Resisting System

Lateral resistance for the structure in both directions is provided through the concrete masonry walls.

5 Survey

The structure currently has no placard (one not issued as part of this inspection).

No copies of the design calculations or structural drawings have been obtained for this structure however we have measured the structure accurately and made calculations based on these figures.

Non-intrusive inspections have been used to confirm the structural systems, and to identify details which required particular attention.

6 Damage Assessment

The building has damage that appears to have been the result of the recent earthquake events.

6.1 Differential Settlement

The building has a lean of 10 degrees from south to north with a height variation of 150mm across the floor slab.

The toilet building and concrete grey water collection box have separated by approximately 30mm.

6.2 Ground Slab/Foundation Cracking

Cracks with widths of 3mm to 5mm have formed in the concrete access ramp.

7 General Observations

The superstructure has performed well under seismic conditions, though the foundations have been subject to the effects of liquefaction resulting in lateral spreading and differential settlement of 150mm.

8 Detailed Seismic Assessment

8.1 Seismic Coefficient Parameters

The seismic design parameters based on current design requirements from NZS1170.5:2004 and the NZBC clause B1 for this structure are:

- Site soil class D, clause 3.1.3 NZS 1170.5:2004
- Site hazard factor, Z=0.3, B1/VM1 clause 2.2.14B
- Return period factor R_u = 1.0 from Table 3.5, NZS 1170.5:2004, for an Importance Level 2 structure with a 50 year design life.
- Ductility factor $\square_{max}$ = 1.25 for the concrete masonry building.

8.2 Detailed Seismic Assessment Results

For the purpose of assessment we have assumed that the concrete masonry walls are partially filled only with 10mm diameter vertical reinforcing bars at 600mm centres.

A summary of the structural performance of the structure is shown in the following table. Note that the values given represent the worst performing elements in the structure, as these effectively define the structure's capacity. Other elements within the structure 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	%NBS based on calculated capacity
Transverse direction, north-south direction	Moment capacity of the walls Shear capacity of the walls	75% >100%
Longitudinal direction, east-west direction	Moment capacity of the walls Shear capacity of the walls Out-of-Plane moment capacity of the western wall	>100% >100% 51%

8.3 Discussion of Results

The structure has a calculated capacity of greater than 51%NBS. This is above the threshold limit for structures classified as 'Earthquake Prone' which is one third (33%) of the seismic performance specified in the current loading standard for new structures (New Building Standard, or NBS). The structure is therefore classed as having a moderate earthquake risk in accordance with the NZSEE guidelines.

The structure of the roof does not provide a diaphragm and as such the western wall must support itself out-of-plane as well as in plane. It is the out-of-plane capacity of this wall which restricts the %NBS of the structure.

The differential settlement of the building is such as to meet the foundation rebuild indicator criteria of the Department of Building and Housing guidance on the repairing and rebuilding of houses affected by the Canterbury Earthquakes [6].

8.4 Limitations and Assumptions in Results

The observed level of damage suffered by the building was deemed low enough to not affect the capacity. Therefore the analysis and assessment of the building was based on it being in an undamaged state. There may have been damage to the building that was unable to be observed during assessments that could cause the capacity of the building to be reduced; therefore the current capacity of the buildings 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; and
- without an intrusive investigation the capacity of the foundation cannot be determined but, due to the small loads being imparted on them, it is assumed that their capacity is greater than 100%NBS.

9 Geotechnical Assessment

The following is a summary of the attached Geotechnical Desktop Study in Appendix C.

9.1 Site Description

The toilet building is located adjacent to the BMX Track in Bexley Park located off Pages Road. The toilets are located on a relatively flat site. There is a small creek, which runs alongside Anzac Drive SH74, located approximately 26m behind the toilets. The invert of the creek is approximately 2m below the floor level of the toilets.

9.2 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 underlain by alluvial sand and silt overbank deposits belonging to the Yaldhurst Member of the Springston formation.

9.3 Expected Ground Conditions

A review of the Environmental Canterbury (ECan) wells database showed one well located within approximately 120m of the property. The locations of Boreholes and Cone Penetrometer Test's (CPT) undertaken by the Earthquake Commission (EQC) have been reviewed. Two CPT's and one Borehole have been identified approximately 220m from the building. Material logs available from the above sources have been used to infer the ground conditions at the site, as shown in Table 3 below.

Table 3: Inferred Ground Conditions.

Stratigraphy	Thickness	Depth Encountered from bgl
SILT	2.5m	Surface
SAND	2.5-24m	2.5m
GRAVEL	-	24m

9.4 Liquefaction Hazard

The 2004 Environment Canterbury Solid Facts Liquefaction Study indicates the site is in an area designated as having 'moderate liquefaction ground damage potential'.

The Department of Building and Housing (DBH) zoned Christchurch into three technical categories (TC) on 28 October 2011. Bexley Park has been zoned as a Green Zone-N/A-Urban Non-residential, as it does not accommodate a residential dwelling. However, the residential properties in the suburb of Bexley 80m to the east, opposite SH74 Anzac Drive, have been placed in the Red Zone as impractical to repair.

9.5 Site Observations

A site walkover inspection was carried out by an Opus Geotechnical Engineer on 17 June 2012.

The following observations were made (refer to the Geotechnical Desktop Study attached to this report for photographs):

- Remnant liquefaction ejecta is evident in the vicinity of the toilet block, particularly in the grassed area to the west, 6m of the toilet block;
- The toilet block appears to have undergone approximately 150mm of differential settlement;
- A 3mm to 5mm wide crack runs across the southern end of the concrete ramp;

- A gap of approximately 50mm wide has formed along the western elevation of the concrete ramp;
- A void was observed under the southern end of the concrete ramp exposing the concrete piles;
- The toilet building and adjacent water collection box have been laterally separated by approximately 30mm;
- A manhole immediately to the north of the toilet block appears to have heaved by approximately 100mm;
- Minor cracks in the soil, approximately 15mm wide were observed in the grassed area to 8m north of the toilet block.
- A void approximately 500mm wide was observed in the tree line approximately 12 metres behind the toilet block.

9.6 Conclusions and Discussion

As a result of the 4th September 2010 Canterbury Earthquake and the following aftershocks; differential settlement and cracking has occurred in the vicinity of the Bexley Park BMX Track toilet block. The site has been affected by liquefaction damage in at least four seismic events.

No cracks were observed within the perimeter footing. Differential settlement of 150mm was observed in the toilet building.

Due to the differential settlement there is void underneath the southern end of the toilet structure and the concrete access ramp. It was impossible to determine the extent of the void.

There is a gap between the ground and the western side of approximately 50mm. This gap is either due to lateral spread to the creek, or from horizontal consolidation induced from the movement of the toilets in the earthquakes. The 30mm separation between the toilet's structure and the concrete grey water collection box also shows that the building has moved.

Available literature and studies have indicated that soils at this site may have a moderate risk of liquefaction occurring during a large earthquake event. The aerial photographic records, site observations and the DBH Technical Category Zonation confirm that extensive liquefaction has occurred in the area of the Bexley Park BMX Track toilets, due to the Canterbury Earthquake Sequence following the 4 September 2010 earthquake.

10 Remedial Options

Any remedial options for increasing the seismic capacity to at least 67%NBS would need to address the out-of-plane capacity of the western wall and the significant differential settlement across the building.

11 Conclusions

(a) The building structure has a seismic capacity of 51%NBS, governed by the out-of-plane moment capacity of the western wall, and therefore has a moderate earthquake risk.

(b) Due to the calculated capacity the building is classed as grade C, moderate risk, and has a relative risk of failure of approximately 7 times that of building complying with current codes.

(c) Some land damage has occurred in the surrounding area and the building foundations have failed due to liquefaction induced differential settlement.

12 Recommendations

a) The building and grey water collection box could be re-levelled, though this does not address the risk of differential settlement recurring in future seismic events;

The access ramp could be partially demolished and reconstructed to suit the new building level.

The building should also be strengthened to at least 67%NBS.

b) Alternatively, the building could be demolished and replaced. New foundations could be a shallow raft type foundation (with provision to allow re-levelling if there is future liquefaction induced settlement), or deep to minimise liquefaction induced settlement.

The second option of demolishing and replacing may be preferable at this site as repair is likely to be difficult and expensive due to the ground conditions and building type.

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.

(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 structures and facilities. It is not intended for any other party or purpose.

14 References

[1] NZS 1170.5: 2004, *Structural design actions, Part 5 Earthquake actions,* Standards New Zealand.

[2] NZSEE: 2006, *Assessment and improvement of the structural performance of buildings in earthquakes,* New Zealand Society for Earthquake Engineering.

[3] Engineering Advisory Group, *Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure*, Draft Prepared by the Engineering Advisory Group, Revision 5, 19 July 2011.

[4] Engineering Advisory Group, *Guidance on Detailed Engineering Evaluation of Non-residential buildings, Part 3 Technical Guidance*, Draft Prepared by the Engineering Advisory Group, 13 December 2011.

[5] SESOC, *Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes*, Structural Engineering Society of New Zealand, 21 December 2011.

[6] Department of Building and Housing, *Revised guidance on repairing and rebuilding houses affected by the Canterbury earthquake sequence*, November 2011

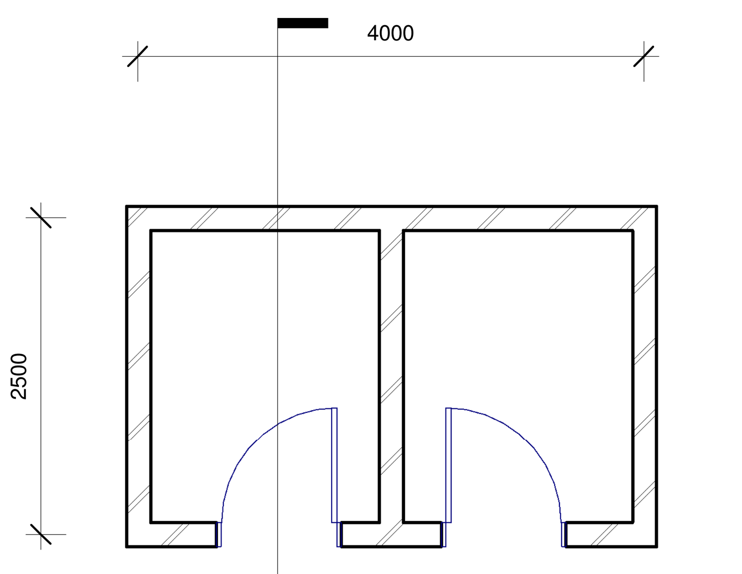
Appendix A – Photographs

Photo 1: The north and west wall of the building.

Photo 2: The north and east wall of the building.

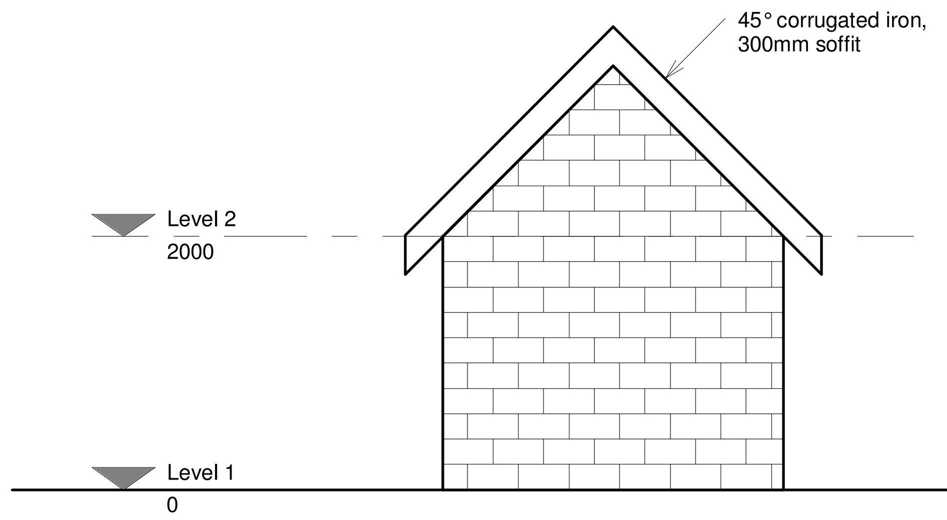
Photo 3: Separation of 30mm between the toilets and the concrete grey water collection box.

Appendix B – Building Plan

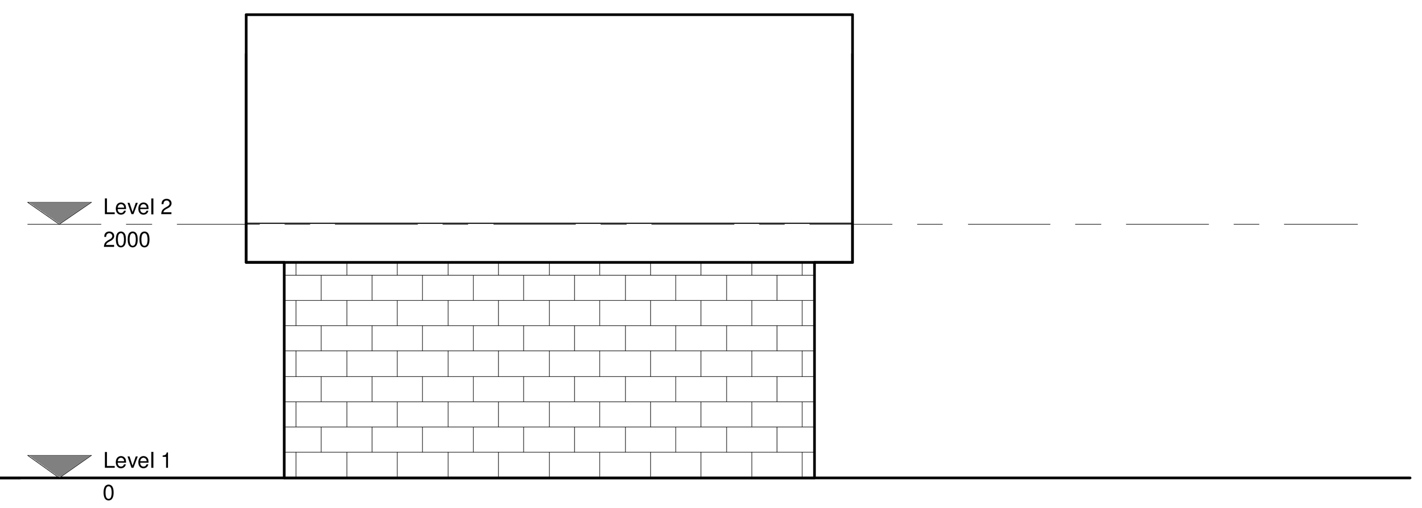


6 A200

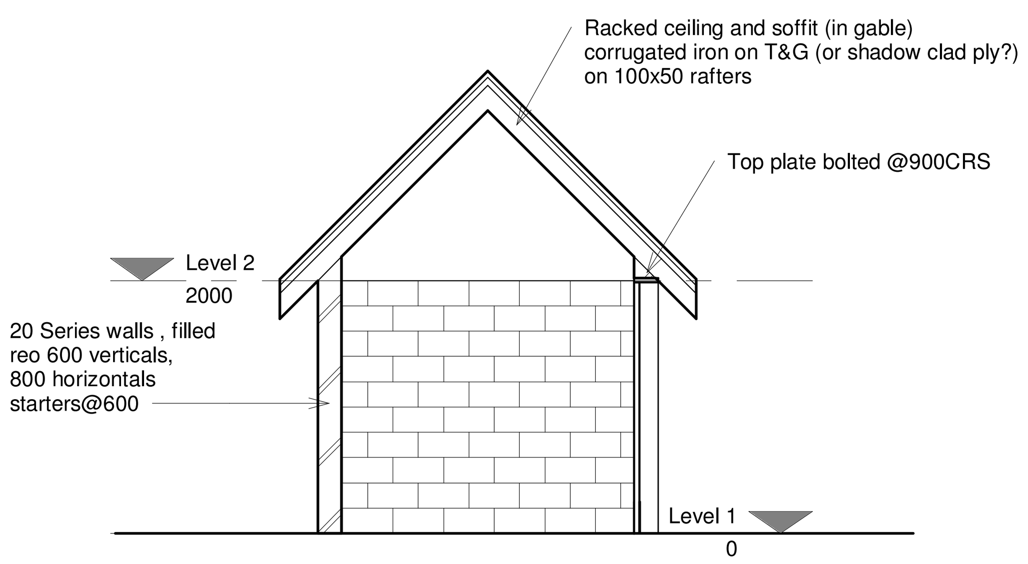
1 A200 **Level 1 Plan** 1 : 50



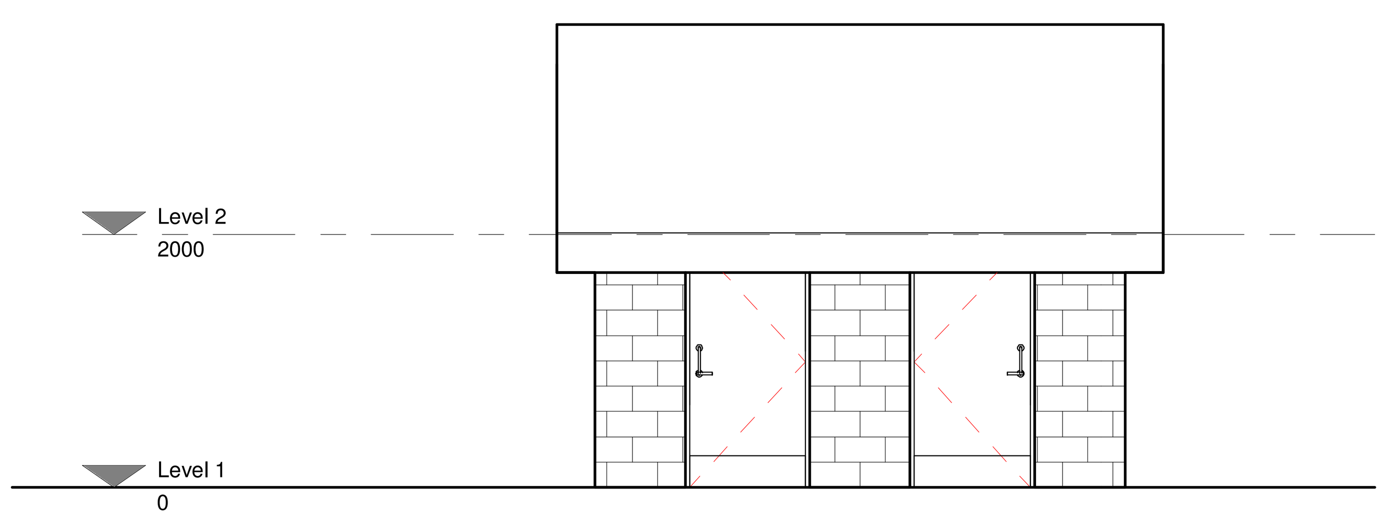
2 **East Elevation** 1 : 50



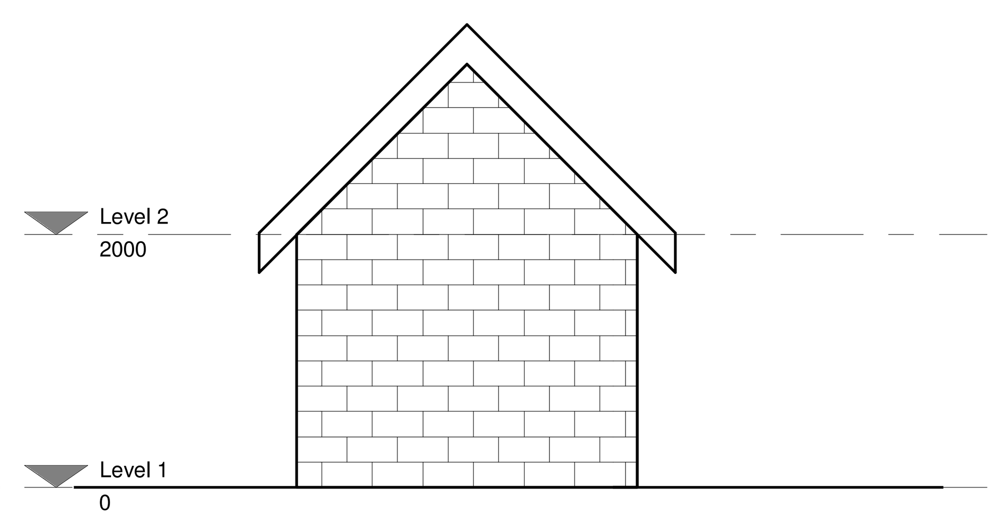
3 **North Elevation** 1 : 50



6 A200 **Section** 1 : 50



4 **South Elevation** 1 : 50



5 **West Elevation** 1 : 50

Draft

Revision	Amendment	Approved	Revision Date

OPUS
Christchurch Office
+64 3 363 5400
PO Box 1482
Christchurch 8140
New Zealand

Drawn	Designed	Approved	Revision Date
A.Senior			

Project: CCC
Bexley Park, Christchurch
BMX Park Toilets

Title: Existing Floor Plan, Elevations, Section

Project No.	Scale	Drawing No.	Sheet No.	Revision
6-QUCC1.37	1 : 50	6/1366/325/8602	A200	RA

Appendix C – Geotechnical Assessment

Geotechnical Desk Study – Bexley Park BMX Toilet Block

1. Introduction

Christchurch City Council (CCC) has commissioned Opus International Consultants (Opus) to undertake a Geotechnical Desk Study and Site Walkover of the Bexley Park BMX Track Toilets, Christchurch. The purpose of this study is to: collate existing subsoil information, undertake an appraisal of the potential geotechnical hazards at this site and determine whether further investigations are required. The site walkover was completed by an Opus Engineer on 17 July 2012.

This Geotechnical Desk study has been prepared in accordance with the Engineering Advisory Group's Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury on 19 April 2012. This document forms a part of a Detailed Engineering Evaluation prepared by Opus, and has been undertaken without the benefit of any site specific investigations and therefore preliminary in nature.

2. Desktop Study

2.1 Site Description

The Toilets are located adjacent to the BMX Track in Bexley Park located adjacent to Pages Road, Bexley (refer to the Site Location Plan in Appendix A). The structure is located on a relatively flat site. There is a small creek, which runs alongside Anzac Drive SH74, approximately 26m west the toilets. The invert of the creek is approximately 2m below the floor level of the toilet block.

The structure is constructed of reinforced masonry blocks and occupies a footprint of approximately 11m^2. Observations suggest that the ramp adjacent to the building is founded on concrete piles that are approximately 100mm square to an unknown depth, which may suggest that the building is also founded on piles.

2.2 Structural Drawings

No as-built structural drawings illustrating details of the existing building foundations have been available for review.

2.3 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 underlain by alluvial sand and silt overbank deposits belonging to the Yaldhurst Member of the Springston formation.

A groundwater table depth of 1m has been indicated on the Groundwater Surface Depth map (Canterbury Geotechnical Database, 2012).

2.4 Expected Ground Conditions

A review of the Environmental Canterbury (ECan) wells database showed one well located within approximately 120m of the property (refer to Appendix A). The locations of Boreholes and Cone Penetrometer Test's (CPT) undertaken by the Earthquake Commission (EQC) have been reviewed. Two CPT's and one Borehole have been identified approximately 220m from the building (refer to the Site Location Plan and Appendix B).

Material logs available from the above sources have been used to infer the ground conditions at the site, as shown in Table 1 below.

Table 1: Inferred Ground Conditions.

Stratigraphy	Thickness	Depth Encountered from bgl
SILT	2.5m	Surface
SAND	2.5-24m	2.5m
GRAVEL	-	24m

Standard Penetration Tests (SPT) was undertaken at 1.5m intervals in Borehole BH-BEX-05. SPT 'N' values varied from 4 to 12 over the top 15m of underlying soil, which would indicate the underlying sand layer varies from loose to medium dense.

2.5 Liquefaction Hazard

A liquefaction hazard study was conducted by the Canterbury Regional Council (ECan) in 2004 to identify areas of Christchurch susceptible to liquefaction during an earthquake. The toilet block is located in an area identified as having 'Moderate liquefaction ground damage potential', for a low ground water scenario. Moderate ground damage potential indicates the ground may be affected by 100mm to 300mm of subsidence in a future seismic event.

Examination of post-earthquake aerial photos taken by New Zealand Aerial Mapping (Project Orbit) identified significant evidence of liquefaction ejecta at the site following the September 2010, February 2011, June 2011 and December 2011 seismic events.

EQC mapping indicates four ground cracks (approximately 50-200mm wide), in the vicinity of the building. The cracks are located approximately 30m to 110m southwest of the building.

The Department of Building and Housing (DBH) have sub-divided Christchurch residential properties into Technical Categories (TC). Bexley Park has been zoned as a Green Zone-N/A-Urban Non-residential, as it is Council owned land. However, the residential properties in the suburb of Bexley 80m to the east have been assessed and zoned Red, as it is considered uneconomical to repair or rebuild on this land

3. Site Walkover Inspection

A walkover inspection of the exterior of the building and surrounding land was carried out by an Opus Geotechnical Engineer on 17 July 2012. The following observations were made (refer to Site Photographs and Site Walkover Plan attached to this report):

- Remnant liquefaction ejecta is evident in the vicinity of the toilet block, particularly in the grassed area to the west, 6m of the toilet block (Photograph 6);
- The toilet block appears to have undergone approximately 150mm of differential settlement (Photographs 8 and 9);
- A 3mm to 5mm wide crack runs across the southern end of the concrete ramp (Photograph 11);
- A gap of approximately 50mm wide has formed along the western elevation of the concrete ramp (Photograph 12);
- A void was observed under the southern end of the concrete ramp exposing the concrete piles (Photograph 13);
- The toilet building and adjacent water collection box have been laterally separated by approximately 30mm (Photograph 16);
- A manhole immediately to the north of the toilet block appears to have heaved by approximately 100mm (Photograph 17);
- Minor cracks in the soil, approximately 15mm wide were observed in the grassed area to 8m north of the toilet block (Photograph 18).
- A void approximately 500mm wide was observed in the tree line approximately 12 metres behind the toilet block (Photograph 19).

4. Discussion

As a result of the 4th September 2010 Canterbury Earthquake and the following aftershocks; differential settlement and cracking has occurred in the vicinity of the Bexley Park BMX Track toilet block. The site has been affected by liquefaction damage in at least four seismic events.

The existing toilet block appears to be founded on square concrete piles to an unknown depth. No cracks were observed along the concrete capping beam. Visual observations suggest that the toilet block has experienced approximately 150mm of differential settlement towards the north.

Observations also suggest that the ground surrounding the toilet block has undergone liquefaction induced settlement and lateral spreading. The lateral spreading appears to have occurred in regions between the toilet block and surrounding free-faces (streams) as indicated by the tension cracks in the vicinity.

The 50mm gap between the surrounding soils and the western elevation is likely to have been caused due to the lateral consolidation of the soil during the seismic shaking of the structure.

Cracking, possibly due to lateral spread, was observed running parallel to the creek along the edge of the grass area to the north of the toilets. The 30mm separation between the toilets structure and the concrete grey water collection box also shows that the toilets have moved. A series of minor lateral cracks were identified along the tree line, to the north west of the toilets. The cracks appear to be due to lateral spread towards the small creek.

Liquefaction typically occurs in recent normally consolidated silts and sands beneath the water table and is dependent on material density, grain size and soil composition. The nearby borehole and CPT's indicates soils at the site comprise silty topsoil underlain by a thick sand layer. The relatively high groundwater table at the site (approximately 1m), and the sandy soils present indicate that the soils at this site are highly susceptible to liquefaction.

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 (GNS, 2012) indicates there is a 13% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. This confirms that there is currently a significant risk of another potentially damaging earthquake occurring. Further liquefaction at this site is possible in such an event, dependant on the location of the epicentre. However, it is expected that the probability of occurrence is likely to reduce with time, following periods of reduced seismic activity.

Flooding and tidal risks to this site have not been assessed as part of this geotechnical desk study.

No site specific investigations have been available for review at the time of reporting,

No level survey, vertically survey or site investigations have been undertaken as part of this Geotechnical Desk Study.

5. Conclusions

The existing foundations appear to have differentially settled by approximately 150mm following the Christchurch earthquake sequence of 2010 and 2011, which suggest that the current foundations are not appropriate for this site.

There are a number of options which could be adopted for the remediation of this toilet block. If the toilet block was left in its current position on the current foundations, CCC would need to accept that the building is likely to settle further in future significant seismic events. Further settlement is likely to be low risk to life. Future damage to the blocks services is likely with future land damage.

If rebuilding the toilet block is required, lightweight materials are recommended to reduce the load distributed to the underlying soil. The toilet block should also be built further away from the adjacent streams to reduce the damage induced from lateral spreading.

Site specific investigations will be required for the detailed design phase.

6. Limitations

This report has been prepared solely for the benefit of Christchurch City Council as our client with respect to the particular brief given to us. Data or opinions in this desk study may not be used in other contexts, by any other party or for any other purpose.

It is recognised that the passage of time affects the information and assessment provided in this Document. Opus's opinions are based upon information that existed at the time of the production of this Desk Study. It is understood that the Services provided allowed Opus to form no more than an opinion on the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings or any laws or regulations.

7. References

Brown, LJ; Webber, JH 1992: Geology of the Christchurch Urban Area. Scale 1:25,000. Institute of Geological and Nuclear Sciences geological map, 1 sheet + 104p. Institute of Geological and Nuclear Sciences Limited, Lower Hutt, New Zealand

Environment Canterbury, Canterbury Regional Council (ECan) website:

ECan Well Card

http://ecan.govt.nz/services/online-services/tools-calculators/Pages/well-card.aspx

ECan 2004: The Soild Facts on Christchurch Liquefaction. Canterbury Regional Council, Christchurch, 1 sheet.

Project Orbit, 2011: Interagency/organisation collaboration portal for Christchurch recovery effort. https://canterburyrecovery.projectorbit.com/SitePages/Home.aspx

GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury-quakes/aftershocks/ updated on 7 September 2012.

Canterbury Geotechnical Database (2012) "Event Specific Groundwater Surface Elevations", Map Layer CGD0800 - 16 Aug 2012, retrieved 26 October 2012. From https://canterburygeotechnicaldatabase.projectorbit.com/

Appendices:

Appendix A: Site Location Plan
Appendix B: Site Photographs
Appendix C: Borehole Logs
Appendix D: Logs

Appendix A:
Site Plan

SOURCE: canterburyrecovery.projectorbit.com (Accessed on 19/07/12)

Scale approx 1 to 1500 at A3

Symbol	Legend
Red circle	Borehole Location
Red star	CPT Test Location
Red rectangle	Location of Bexley Park BMX Track Toilets

BH ref	Borehole Number
1	BH-BEX-05

CPT ref	CPT Number
A	CPT-BEX-01
B	CPT-BEX-23

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: Bexley Park - BMX Track Toilets Geotechnical Desk Study

Project No.: 6-QUCC1.37

Client: Christchurch City Council

Site Location Plan

Drawn: Opus Geotechnical Engineer

Date: 18-Jul-12

Appendix B:
Site Photographs

Photograph 1. Western Elevation (Entrance to toilet from BMX track).

Photograph 2. Southern Elevation.

Photograph 3. Eastern Elevation, showing differential settlement from south to north.

Photograph 4. Northern Elevation.

Photo 5: From tree line to the east of the toilets looking to the small creek (red arrow) by Anzac Drive.

Photograph 6. Ejected sand from liquefaction on the grassed area to the east of the toilets.

Photograph 7. Ejected sand from liquefaction adjacent to the toilets.

Photograph 8. The top of the perimeter strip footing 230mm above ground level at the southeast corner of the toilets.

Photograph 9. The top of the perimeter strip footing 80mm above ground level at the northeast corner of the toilets.

Photograph 10. Southern end of concrete access ramp.

Photograph 11. 5mm crack across the southern concrete access ramp.

Photograph 12.Separation of 50mm between the ground and the front of the concrete access ramp.

Photograph 13. Void underneath the south-western corner of the concrete access ramp.

Photograph 14. A pile within the void under the south-western corner of the concrete access ramp.

Photograph 15. Void underneath the south-western corner of the toilets.

Photograph 16. Separation of 30mm between the toilets and the concrete grey water collection box.

Photograph 17. Manhole adjacent to the toilets that appears to have risen by approximately 100mm.

Photograph 18. Minor cracking about 15mm wide approximately 6m north of the toilets.

Photograph 19. Collapsed void approximately 500mm wide in the tree line to the east of the toilets.

Appendix C:
Surrounding Site Investigation Data

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BOREHOLE LOG

BOREHOLE No: BEX-05
Hole Location: BH-BEX-05-Bexley
SHEET 1 OF 3

PROJECT: Darfield 2010 Earthquake - EQC Ground Investigations | LOCATION: Bexley | JOB No: 51731.001

CO-ORDINATES 5743116.28 2487403.5
R.L. 1.99 m
DATUM Lyttleton 1937

DRILL TYPE:
DRILL METHOD: Open barrel/concentrix
DRILL FLUID: N/A

HOLE STARTED: 7/12/10
HOLE FINISHED: 7/12/10
DRILLED BY: Perry Drilling
LOGGED BY: ZDP CHECKED: BMcD

Depth (m)	R.L. (m)	Geological unit	Core recovery (%)	Method	Casing	Tests	Samples	Graphic log	Classification symbol	Moisture condition	Strength/density	Soil description
0.0–0.8	1.99	HAND DIG FILL. (Potholed for services check and backfilled.)		SAMPLE BAGGED						W		FILL: Fine to medium SAND with some silt, brown. Wet, well graded. (Borehole drilled through pre-dug and backfilled pothole.)
0.8–1.5		SUBDIVISION CONSTRUCTION FILL	100	OPEN BARREL	65				ML		S	FILL: Sandy SILT with some gravel and trace organics (wood), brown. Wet, low plasticity. Sand is fine to medium. Gravel is angular (fill).
1.5–2.6	0.5	YALDHURST FORMATION (Overbank silt)	36			0/2/1/1/2 N=6; *PSD WS (2.3)	B		ML			SILT with some sand, grey. Wet, low plasticity. Sand is fine. - 1.5m to 1.95m no recovery
2.6–3.0						*FC (2.8)	B		SP		L	Fine SAND with some silt, grey. Wet, poorly graded.
3.0–5.0	-1.0	CHRISTCHURCH FORMATION (Coastal sand)	100			1/1/1/2/3 N=7 (3.0); *FC (3.8); *FC (4.4); 0/1/2/3/4 N=10 (4.5)	B; B		SP			Fine SAND, grey. Wet, poorly graded.

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: BEX-05
Hole Location:
BH-BEX-05-Bexley

PROJECT: Darfield 2010 Earthquake - EQC Ground Investigations | LOCATION: Bexley | JOB No: 51731.001

CO-ORDINATES 5743116.28 2487403.5 | DRILL TYPE: | HOLE STARTED: 7/12/10
R.L. 1.99 m | DRILL METHOD: Open barrel/concentrix | HOLE FINISHED: 7/12/10
DATUM Lyttleton 1937 | DRILL FLUID: N/A | DRILLED BY: Perry Drilling | LOGGED BY: ZDP | CHECKED: BMcD

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
CHRISTCHURCH FORMATION (Coastal sand)	100	OPEN BARREL	65					SP	W	L	Fine SAND, grey. Wet, poorly graded.
						-3.5	5.5				
	100			4/1/2/3/2 N=8		-4.0	6.0				
						-4.5	6.5				
				✱FC	B	-5.0	7.0				- 6.5m to 7.5m trace silt
	100			3/3/4/3/2 N=12		-5.5	7.5			MD	
						-6.0	8.0				
				✱FC	B						
						-6.5	8.5				
				✱PSD WS	B						
	100			3/3/4/2/2 N=11		-7.0	9.0				
						-7.5	9.5				
				✱FC	B		10				

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: BEX-05
Hole Location:
BH-BEX-05-Bexley

SHEET 3 OF 3

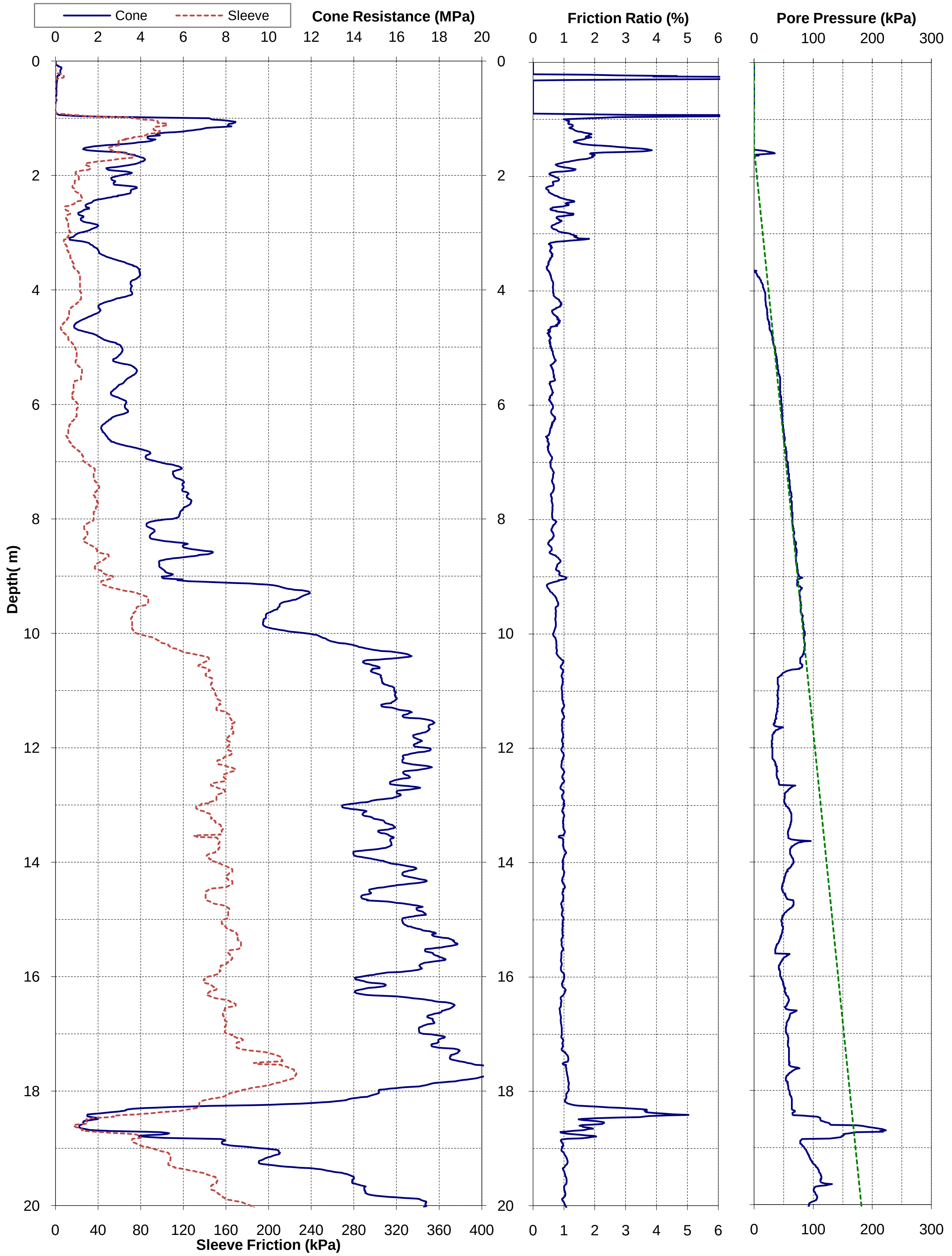
PROJECT: Darfield 2010 Earthquake - EQC Ground Investigations		LOCATION: Bexley	JOB No: 51731.001
CO-ORDINATES	5743116.28 2487403.5	DRILL TYPE:	HOLE STARTED: 7/12/10
		DRILL METHOD: Open barrel/concentrix	HOLE FINISHED: 7/12/10
R.L.	1.99 m		DRILLED BY: Perry Drilling
DATUM	Lyttleton 1937	DRILL FLUID: N/A	LOGGED BY: ZDP CHECKED: BMcD

GEOLOGICAL | ENGINEERING DESCRIPTION

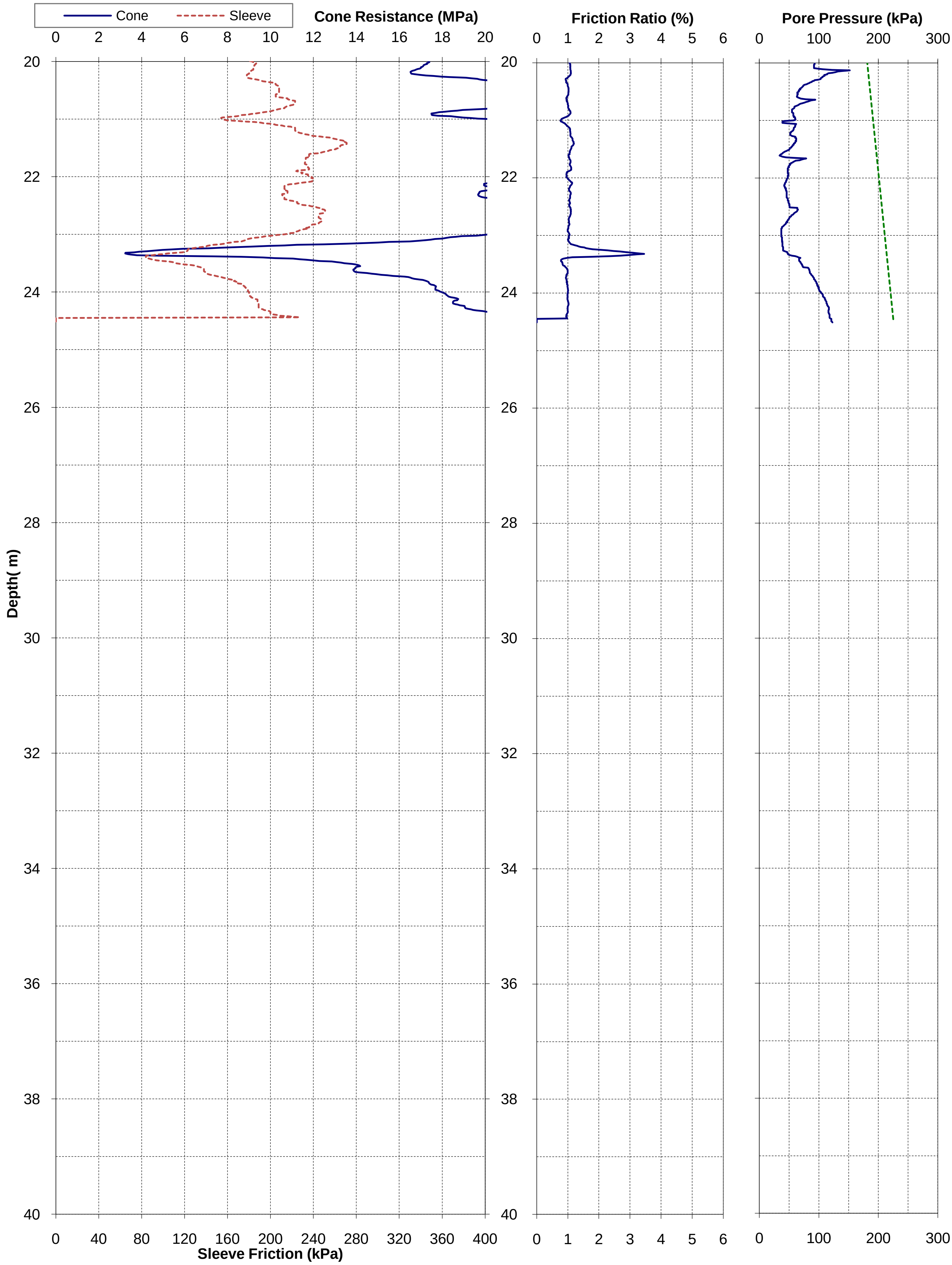
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION \ WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION (Soil type, minor components, plasticity or particle size, colour.) / ROCK DESCRIPTION (Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.)
CHRISTCHURCH FORMATION (Coastal sand)		OPEN BARREL	65					sand	SP	W	MD	Fine SAND, grey. Wet, poorly graded.
				✱FC	B							
	100			3/2/4/4/4 N=14		-8.5	10.5					
						-9.0	11.0					
						-9.5	11.5					
	100			2/2/2/2/3 N=9		-10.0	12.0				L	
						-10.5	12.5					
						-11.0	13.0					
	100			2/0/1/1/2 N=4		-11.5	13.5					- potentially low N value due to drilling difficulties
						-12.0	14.0					- 14.1m to 14.3 trace shells
						-12.5	14.5					
				3/4/6/7/11 N=28			15				D	**End of borehole at 15mbgl.**

Appendix D:
Logs

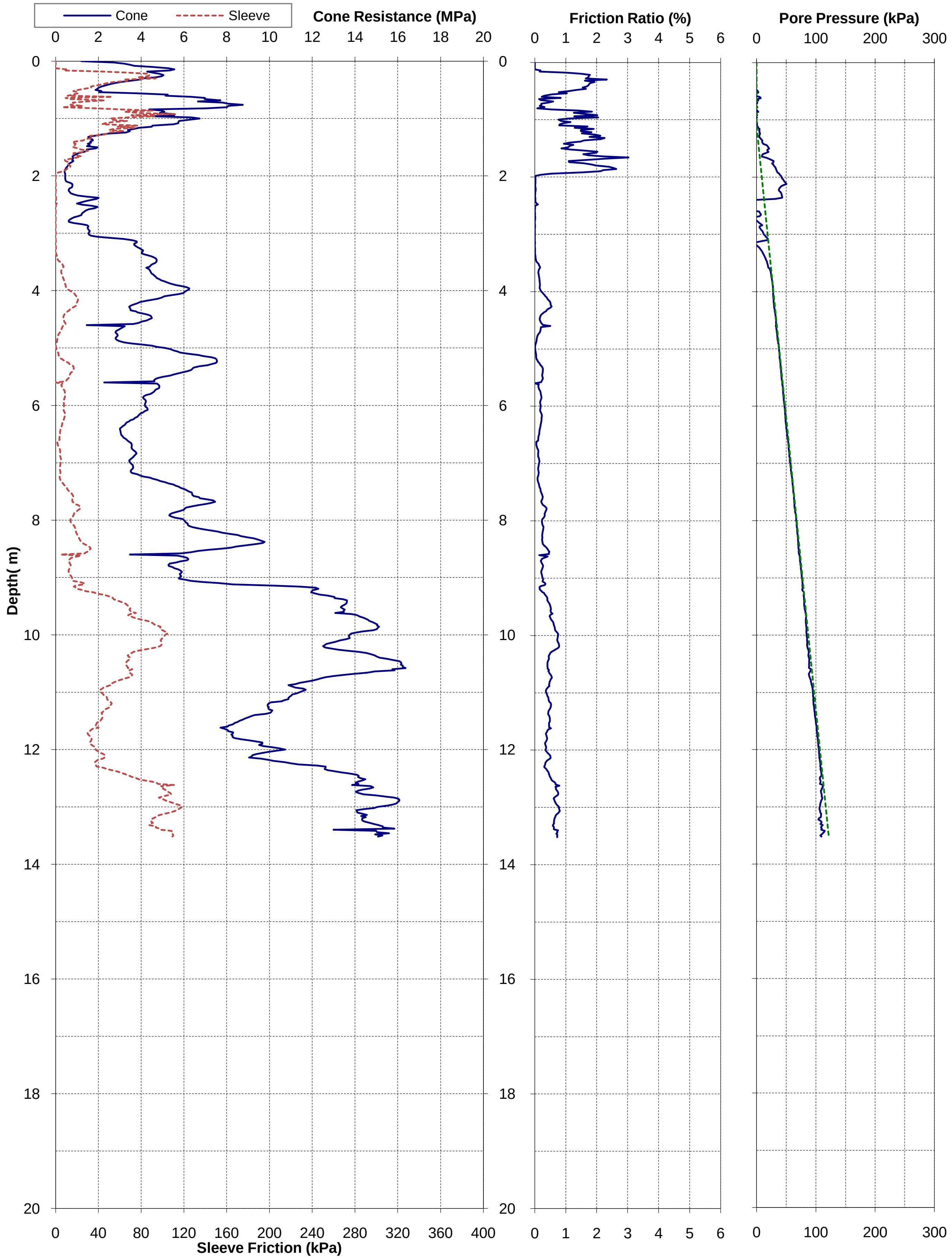
Project:	Darfield 2010 Earthquake - EQC Ground Investigations			**Page:** 1 of 2	**CPT-BEX-01**
Test Date:	3-Nov-2010	**Location:**	Bexley	**Operator:**	Perry
Pre-Drill:	0.8m	**Assumed GWL:**	1.5mBGL	**Located By:**	Survey GPS
Position:	2487413.1mE	5743122.4mN	1.96mRL	**Coord. System:**	NZMG & MSL
Other Tests:				**Comments:**	



Project:	Darfield 2010 Earthquake - EQC Ground Investigations			Page: 2 of 2		CPT-BEX-01
Test Date:	3-Nov-2010	Location:	Bexley	Operator:	Perry	
Pre-Drill:	0.8m	Assumed GWL:	1.5mBGL	Located By:	Survey GPS	
Position:	2487413.1mE	5743122.4mN	1.96mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		



Project:	Darfield 2010 Earthquake - EQC Ground Investigations			Page: 1 of 1		CPT-BEX-23
Test Date:	30-Sep-2010	Location:	Bexley	Operator:	Geotech	
Pre-Drill:	0m	Assumed GWL:	1.1mBGL	Located By:	Survey GPS	
Position:	2487407.7mE	5743147.6mN	1.918mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		



Appendix D – CERA DEEP Data Sheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Bexley Park BMX Track Toilets	Reviewer:	Dave Dekker
	Unit / No: / Street	CPEng No:	1003026
Building Address:	Pages Road	Company:	Opus International Consultants
Legal Description:		Company project number:	6QUCC1.37
		Company phone number:	03 363 5400
	Degrees / Min / Sec		
GPS south:		Date of submission:	4-Feb-13
GPS east:		Inspection Date:	17-Jun-12
		Revision:	Final
Building Unique Identifier (CCC):	PRK 1385 BLDG 002 EQ2	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:	silty sand	Soil Profile (if available):	
Site Class (to NZS1170.5):	D		
Proximity to waterway (m, if <100m):	30	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):	0.50
Storeys below ground			
Foundation type:	raft slab	if Foundation type is other, describe:	
Building height (m):	3.75	height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	10		
Age of Building (years):		Date of design:	
Strengthening present?	no	If so, when (year)?	
		And what load level (%g)?	
Use (ground floor):	public	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	
Floors:	concrete flat slab	slab thickness (mm)	
Beams:			
Columns:			
Walls:	partially filled concrete masonry	thickness (mm)	200

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	partially filled CMU		note total length of wall at ground (m):	
Ductility assumed, μ:	1.25		wall thickness (m):	
Period along:		##### enter height above at H31	estimate or calculation?	
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	partially filled CMU		note total length of wall at ground (m):	
Ductility assumed, μ:	1.25		wall thickness (m):	
Period across:		##### enter height above at H31	estimate or calculation?	
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:	other heavy	describe	partially filled CMU
Roof Cladding:	Metal	describe	
Glazing:			
Ceilings:	none		
Services(list):			

Available documentation

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

Damage

Site: (refer DEE Table 4-2)

Site performance:		Describe damage:	
Settlement:	0-25mm	notes (if applicable):	
Differential settlement:	1:150 or more	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	50-250mm	notes (if applicable):	
Differential lateral spread:	1:400-1:100	notes (if applicable):	
Ground cracks:	20-100mm/20m	notes (if applicable):	
Damage to area:	moderate to substantial (1 in 5)	notes (if applicable):	

Building:

	Current Placard Status:	green		
Along	Damage ratio:	100%	Describe how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:			
	Describe (summary):			
Diaphragms	Damage?:		Describe:	
CSWs:	Damage?:		Describe:	
Pounding:	Damage?:	yes	Describe:	Damage to roof parapet on western side of roof
Non-structural:	Damage?:		Describe:	

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

Recommendations

	Level of repair/strengthening required:	minor structural	Describe:	
	Building Consent required:	no	Describe:	
	Interim occupancy recommendations:	do not occupy	Describe:	
Along	Assessed %NBS before:	75% ##### %NBS from IEP below	If IEP not used, please detail assessment methodology:	
	Assessed %NBS after:			
Across	Assessed %NBS before:	51% ##### %NBS from IEP below		
	Assessed %NBS after:			

OPUS