OPUS

Christchurch City Council

Barnett Park Toilets
PRK 1390 BLDG 002

Detailed Engineering Evaluation

Quantitative Assessment Report

Christchurch City Council

Barnett Park Toilets

Quantitative Assessment Report

Sumner, Christchurch

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Summary

Barnett Park Toilets
PRK 1390 BLDG 002

Detailed Engineering Evaluation
Quantitative Report - Summary
Final

Background

This is a summary of the quantitative report for the Barnett Park Toilets and is based on the Detailed Engineering Evaluation Procedure document issued by the Structural Advisory Group of NZSEE on 19 July 2011, visual inspection on 24 April 2012, subsequent cover meter survey on 24 July, 2012 and January 2013, and structural calculations. The 100-115mm thick walls are reinforced concrete with some bricks placed along the top of the concrete wall at the front and rear, through which RHS columns are embedded 150mm into the concrete wall below to support the concrete roof.

Key Damage Observed

Cracking was observed (see photographs in Appendix A) to the exterior of the reinforced concrete perimeter walls and above the interior door lintels. The building has settled approximately 50mm and moved laterally on relatively shallow strip-footing foundations which has caused some foundation cracks.

Critical Structural Weaknesses

No critical structural weaknesses have been identified for this building.

Indicative Building Strength

Based on the information available, and from undertaking a quantitative assessment, the building's capacity has been assessed to be 50%NBS, as limited by the north-south horizontal load-resisting capacity. The bricks located on top of the front concrete wall do not contribute to the overall seismic strength of the building but they are a potential fall hazard.

The capacity of the building is limited by the full height wall layout in the north south direction. In this direction only one 915mm long wall extends to the roof and once this wall capacity is reached the end walls will resist the seismic load in out of plane bending. As the concrete walls are assumed to be reinforced with mesh, when the capacity of the building is reached it is likely to be a brittle failure.

Recommendations

(a) Remove the bricks located on top of the front concrete wall which are a potential fall hazard.

(b) We recommend that strengthening work is undertaken to increase the overall building capacity to at least 67%NBS.

(c) Investigate the services to the toilet to confirm the extent of damage to the water and sewer infrastructure.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Barnett Park toilet building, located in Sumner, Christchurch, following the Canterbury Earthquake Sequence since September 2010.

The purpose of the assessment is to determine if the building is classed as being earthquake prone as defined by the Building Act 2004.

The seismic assessment and reporting have been undertaken based on the qualitative and quantitative procedures detailed in the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) [3] [4].

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 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). CERA have 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.

Christchurch City Council requires any building with a capacity of less than 34% of New Building Standard (including consideration of critical structural weaknesses) to be strengthened to a target of 67% as required under 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).

The Earthquake Prone Building policy for the territorial authority shall apply as outlined in Section 2.3 of this report.

Section 115 – Change of Use

This section requires that the territorial authority 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 territorial authorities as being 67% of the strength of an equivalent new building or as near as practicable. 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

This section defines a building as earthquake prone (EPB) 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.

Where an application for a change of use of a building is made to Council, the building will be required to be strengthened to 67% of New Building Standard or as near as is reasonably practicable.

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:

- increase in the basic seismic design load for the Canterbury earthquake region (Z factor increased to 0.3 equating to an increase of 36 – 47% depending on location within the region);
- 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 responsible 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	Improvement of Structural Performance: Legal Requirement	Improvement of Structural Performance: NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement 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).

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 EPB's. As a result of this, we would expect such a building would be issued with a Section 124 notice, by the Territorial Authority, or CERA acting on their behalf, once they are made aware of our assessment. Based on information received from CERA to date and from the DBH guidance document dated 12 June 2012 [6], this notice is likely to prohibit occupancy of the building (or parts thereof), 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/territorial authority 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.

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

4 Building Description

4.1 General

The building is located at Barnett Park, Sumner, Christchurch, and is a single storey small rectangular reinforced concrete building with a 150mm thick concrete roof slab, designed circa 1980-1990. The building is situated on a flat site and is approximately 7.8m long in the longitudinal north-south direction and 5.0m wide in the transverse east-west direction. The eaves of the roof are approximately 2.7m from the ground. The building is founded on a concrete slab (approximately 125–150mm thick poured over shallow perimeter strip footings, approximately 150mm thick). The 100-115mm thick walls are reinforced concrete with some bricks placed along the top of the concrete wall at the front and rear, through which RHS columns are embedded 150mm into the concrete wall below to support the concrete roof. There is a steel plate acting as a lintel over the door which supports the bricks at the entrance to the ladies toilet in the front wall.

The walls are constructed from 100-115mm thick reinforced concrete with geometry as shown in the as-built drawings by Opus in Appendix B. A cover meter survey indicated the walls are reinforced at 150mm centres each way, which indicates the walls are likely to be reinforced with mesh.

4.2 Gravity Load Resisting System

The heavy concrete roof slab is supported by the concrete end walls, the full height internal concrete walls, and the steel RHS columns above the front and rear walls.

4.3 Seismic Load Resisting System

Seismic loads in east-west direction are resisted by the full height concrete shear walls which are connected to the roof slab.

Seismic loads in the north-south direction are resisted by the 900mm long full height internal concrete wall and the out of plane action of the end walls.

5 Survey

Visual inspections were carried out on 24 April 2012, 24 July 2012 and 23 January 2013.

Due to the non-intrusive nature of the site survey, some connection details and the steel reinforcing details could not be ascertained.

No original design drawings or structural calculations were available for review as part of this assessment.

Photographs and sketches of the building are presented in Appendix A and B.

6 Damage Assessment

The roof and wall systems for the building structure generally suffered only minor damage as a result of the recent earthquake events. However the building has settled approximately 50mm and horizontally moved by up to 50mm and this deformation has damaged the paving around the perimeter of the foundation, and may have resulted in significant damage to underground services to the building, such as plumbing for water supply and waste water disposal.

The roof and wall systems for the building structure generally suffered only minor damage as a result of the recent earthquake events. The concrete walls suffered minor cracking on the exterior and above the interior door lintels. No cracks were visible at the wall/roof junction.

7 General Observations

Overall the building has performed well under seismic conditions, which would be expected for a small single storey structure with reinforced concrete walls. However, the ground adjacent to the building has settled and the building has moved laterally. Repairs will be required to any damaged underground services and the surrounding paving.

The concrete columns forming part of an ornamental portal frame at the north and south ends suffered minimal damage because the relatively stiff transverse east-west concrete walls protected these columns from experiencing large displacements.

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.

No critical structural weaknesses have been identified with this building.

8.2 Seismic Coefficient Parameters

The seismic design parameters based on current design requirements from NZS1170.5:2004 and the NZBC clause B1 for this building 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;
- μ_{max} = 1.0 (assumed that the concrete walls are reinforced with mesh which has a brittle failure mechanism).

- The building was designed in circa 1980-1990 for a seismic hazard factor of Z = 0.22 versus the current code requirement of Z = 0.3 (0.73 times current code.) Building designed for Z = 0.22 and therefore designed for 73% of current code

8.3 Detailed Seismic Assessment Results

A summary of the structural assessment of the building is shown in the table below where an estimate of the %NBS rating is assigned to the major structural elements.

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(s).

Table 2: Summary of Seismic Assessment

Structural Element/System	Failure mode and description of limiting criteria	% NBS based on calculated capacity
Concrete walls in-plane	Capacity of reinforced concrete – north-south walls flexure	72%
Walls out-of-plane	Flexure,	50%
Roof diaphragm	Capacity of the concrete roof	100%
Foundation pad	Resistance to sliding & lateral bearing capacity of the soil	50%

8.4 Discussion of Results

The building has a calculated net capacity of 50%NBS governed by the capacity of the 900mm long internal full height concrete wall and the out of plane capacity of the end walls.

The capacity of the building is limited by the full height wall layout in the north south direction. In this direction only one 915mm long wall extends to the roof and once this wall capacity is reached the end walls will resist the seismic load in out of plane bending. As the concrete walls are assumed to be reinforced with mesh, when the capacity of the building is reached it is likely to be a brittle failure.

The permanent displacement of the building westward by at least 50mm confirms that there is insufficient friction developed and or insufficient horizontal bearing resistance developed by the site soils. This lack of resistance to horizontal foundation movement occurred because the foundations are too shallow. Underground plumbing pipes may well have been damaged by this displacement.

8.5 Limitations and Assumptions in Results

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 fixity and roof diaphragm connectivity;

- Assessments of material strengths based on limited data.
- 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 assuming the quantity of reinforcement present.
- Approximations involved in the Geotechnical Assessment

8.6 Regional Geology

A desktop geotechnical evaluation of the site has been carried out as shown in Appendix C. This report concludes that the local soils should be categorised as class D and the site has moderate liquefaction potential.

8.7 Peak Ground Acceleration and Displacement

Peak accelerations recorded from the 22 February 2011 earthquake were 1.88g (city); 2.2g (near the epicentre, close to Barnett Park, at Heathcote Valley Primary School.) This is the highest PGA ever recorded in New Zealand, but fortunately the duration of strong shaking was relatively short, less than 20 seconds.

Satellite images indicate the net displacement of the land south of the fault was 500mm westwards and upwards; the land movement would have been greater at some locations during the earthquake.

Interpolation of United States Geological Survey (USGS) Shakemap: South Island of New Zealand (22 Feb, 2011) indicates that this location has likely experienced a horizontal Peak Ground Acceleration (PGA) of approximately 1g to 2g during the 22nd February 2011 earthquake.

9 Remedial Options

As the building has a calculated capacity of less than 67% NBS we recommend strengthening works are undertaken to increase the capacity of the building to at least 67% NBS. Possible strengthening and remediation works could include the following:

- Strengthening of the concrete walls to provide additional north-south in plane shear capacity of the concrete walls
- Assessment and repair of the plumbing pipes and surrounding pavement
- Replacement of the bricks located on top of the front concrete wall with a suitable alternative to remove the fall hazard

10 Conclusions

(a) The building has a seismic capacity of 50%, and is therefore classified as an earthquake risk building. The bricks located on top of the front concrete wall do not contribute to the overall seismic strength of the building but they are a potential fall hazard.

(b) The capacity of the building is limited by the full height wall layout in the north south direction. In this direction only one 915mm long wall extends to the roof and once this wall capacity is reached the end walls will resist the seismic load in out of plane bending. As the concrete walls are assumed to be reinforced with mesh, when the capacity of the building is reached it is likely to be a brittle failure.

(c) The signs of settlement of the adjoining pavement, movement of the building and cracking of the surrounding pavement is primarily due to displacement of the structure as it moved horizontally (and vertically) during extreme levels of ground shaking on relatively shallow foundations.

11 Recommendations

(a) Remove the bricks located on top of the front concrete wall which are a potential fall hazard.

(b) We recommend that strengthening work is undertaken to increase the overall building capacity to at least 67%NBS.

(c) Investigate the services to the toilet to confirm the extent of damage to the water and sewer infrastructure.

12 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.

13 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.

Appendix A – Photographs

North and west faces of Barnett Park Toilets

Displacement at front steps

Pavement damage indicating movement of toilet facility

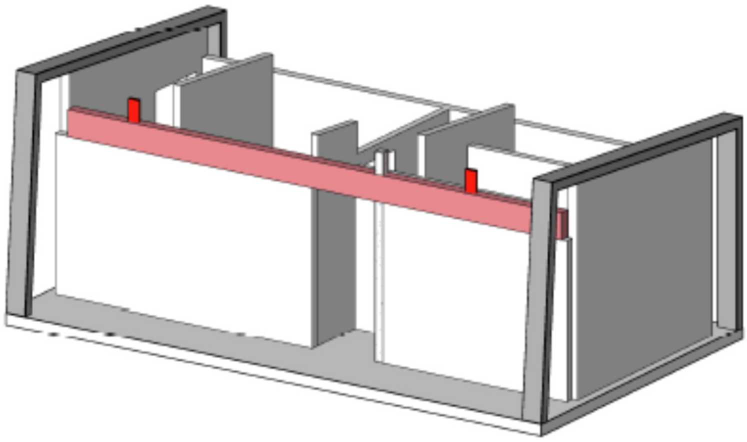
West wall. Note: Concrete wall not full height to roof diaphragm

Rear (east) wall. Note the displacement of the building relative to surrounding slab.

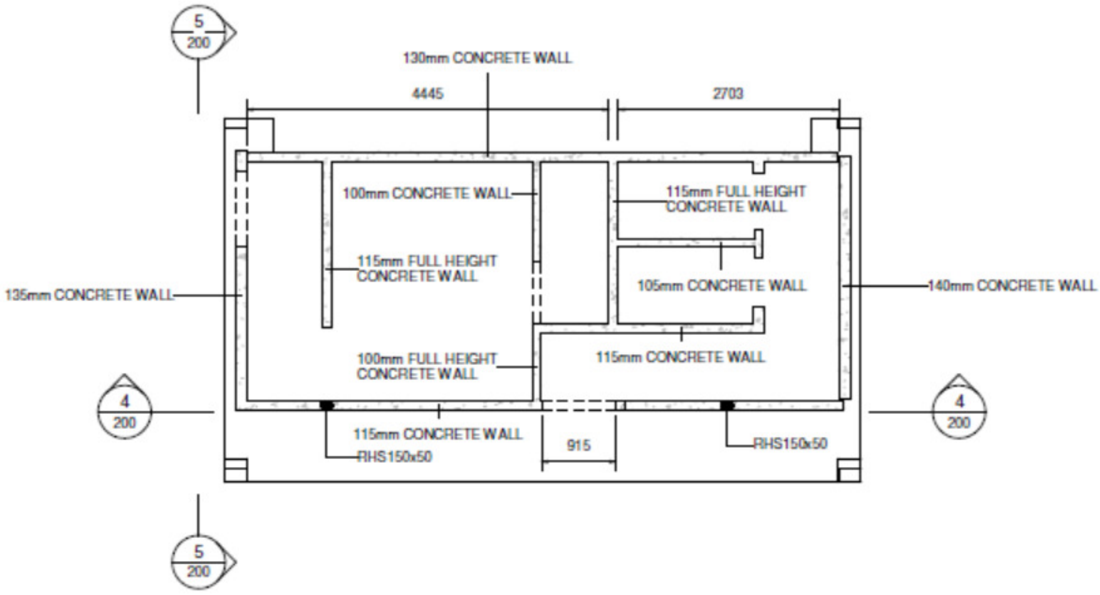
Front side. Note columns on separate foundation than building

Interior 0.9m full-height north-south wall – the only north-south wall that is full-height

Appendix B - Drawings



Structural
SCALE



Floor Plan
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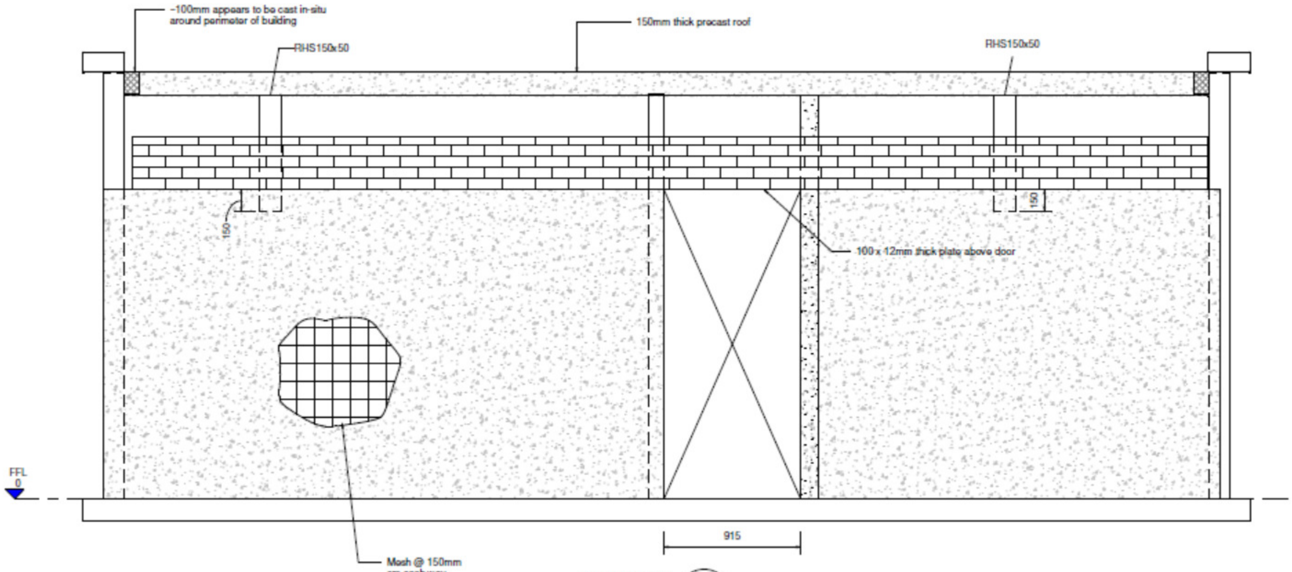

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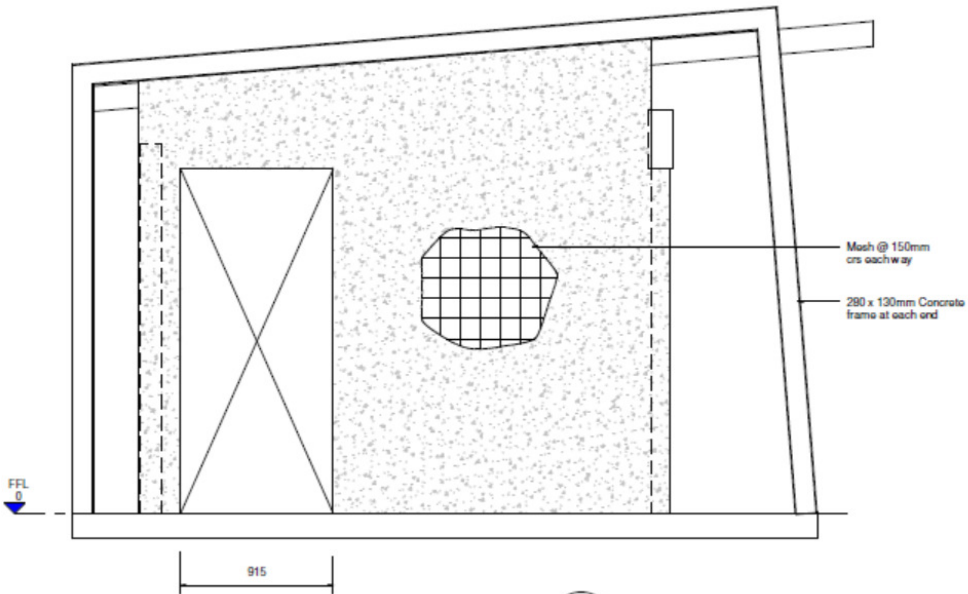

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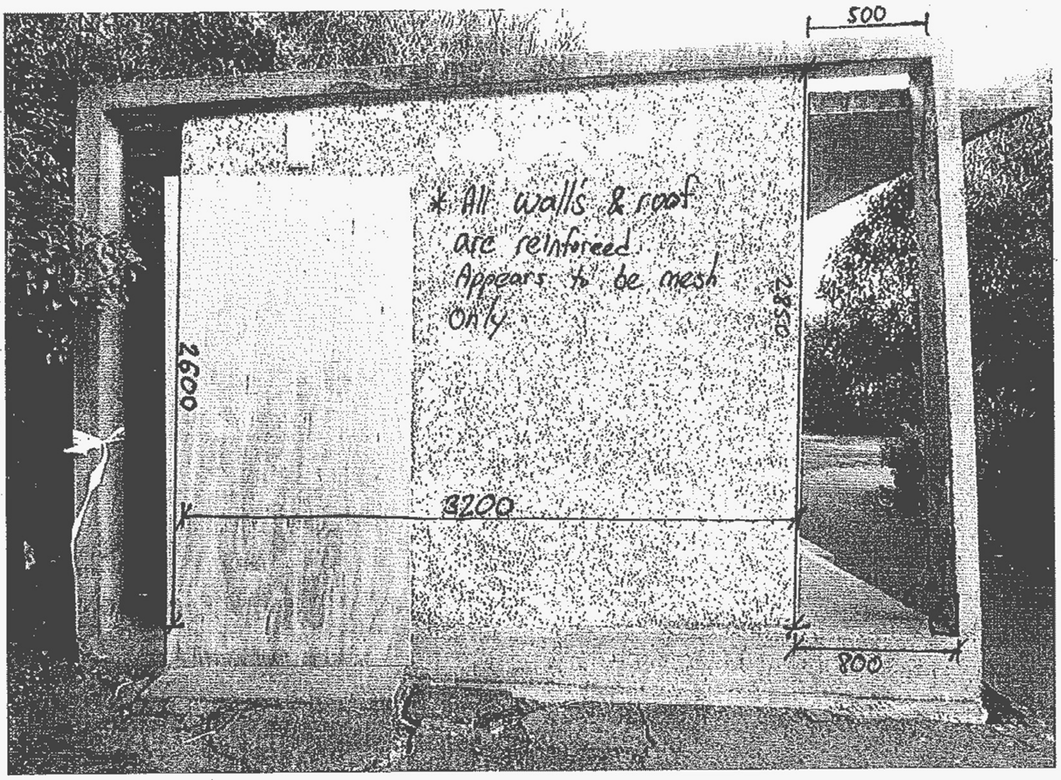
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* All walls & roof
are reinforced
Appears to be mesh
only
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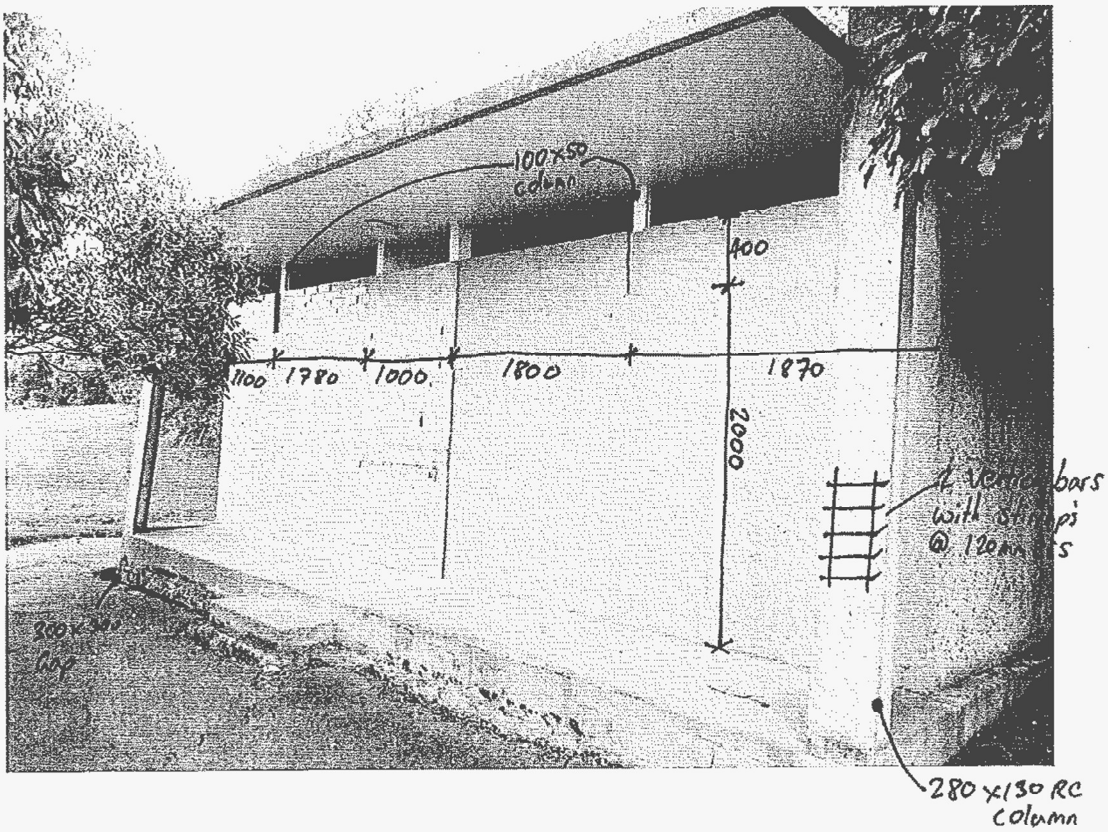
2600
3200
800


100x50
column
400
1100
1780
1000
1800
1870
2000
4 ver… bars
@ 120mm
280 x 130 RC
Column

Appendix C - Geotechnical Report

Geotechnical Desk Study – Barnett Park 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 Barnett Park Toilet Block, Moncks Bay, 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 Opus International Consultants on 19 June 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, Revision 5, 19 July 2011.

This geotechnical desk study has been undertaken without the benefit of any site specific investigations and is therefore preliminary in nature.

2. Desktop Study

2.1 Site Description

The Barnett Park Toilet block is located on the northern boundary of Barnett Park opposite 135 Main Road, Moncks Bay, Christchurch. The toilet block occupies an approximate footprint of 24m2.

The Barnett Park Toilet building is bounded by Main Road to the east and Barnett Park to the South. Cave Terrace bounds the building on the northern and western boundaries.

The ground profile is relatively flat, low lying and is typically level with the surrounding road on the southern and eastern boundaries. The building is situated at the toe of a hill, to which Cave Terrace is cut from. The grounds surrounding the site are generally grassed and planted areas with some paved surfaces.

2.2 Structural Drawings

Extracts from the Structural Drawings have not been available for review. The superstructure is predominantly constructed of concrete tilt-up slabs, and appears to be founded on a thick concrete floor slab that is approximately 400mm thick.

No geotechnical investigations or geotechnical reports associated with the building design were available on the CCC property file.

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 located on dominantly sand of fixed and semi-fixed dunes and beaches.

2.4 Expected Ground Conditions

A review of the Environmental Canterbury (ECan) wells database showed five wells located within approximately 80 m of the property (refer to Site Location Plan in Appendix B). The locations of Boreholes and Cone Penetrometer Test's (CPT) undertaken by the Earthquake Commission (EQC) have been reviewed. No data is available in the vicinity of the building.

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 (m)	Depth Encountered (m)
SAND	1.0-1.5	Surface
SILT	0.3-1.1	1.0-1.5m
SAND(1)	-	1.7-2.1m
Note: (1) Potentially Liquefiable		

A groundwater depth of approximately 0.5m to 1.5m below ground level has been interpreted from groundwater depth contour maps (Brown and Webber (1992)).

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 Barnett Park Toilet Block is located in an area identified as having 'moderate liquefaction ground damage potential', for a low groundwater scenario. Moderate ground damage potential indicates the ground may be affected by 100mm to 300mm of subsidence in a future seismic event.

Tonkin and Taylor Ltd (T&T Ltd) the Earthquake Commission's (EQC) geotechnical consultants have prepared maps showing areas of liquefaction interpreted from high resolution aerial photos for the September 2010 earthquake and the aftershocks of February 2011, June 2011 and December 2011. There has been very minor evidence from these aerial photos of liquefaction on the site or in the vicinity after the after the February 2011 and June 2011 events.

Barnett Park Toilet block has been zoned as N/A-Urban Non-residential. However, the neighbouring residential properties 110m south of the building have been zoned as Green-TC2 "yellow zone", which is determined to have a minor to moderate risk of land damage due to liquefaction in future significant earthquakes. Residential properties 40m east of the building which has been zoned as Green-TC3 "blue zone" indicating moderate to significant risk of land damage due to liquefaction in future significant earthquakes.

2.6 Lateral Spreading Hazard

The estuary is located approximately 100m east of the building. The vicinity of the building, along with the inferred ground conditions indicates there is a moderate lateral spreading hazard at this site.

2.7 Rockfall Hazard

A Port Hills Geotechnical Group Geotechnical Engineer in charge of this area of interest had the following statement (dated 25 June 2012) in regards to the rockfall hazard of this toilet block:

"The 'cliff' behind the toilet block isn't particularly high at that point and should be able to be relatively quickly assessed, I don't anticipate any issues there."

3. Site Walkover Inspection

A walkover inspection of the exterior, interior, and adjacent paved area was carried out by an Opus Geotechnical Engineer on 19 June 2012. The following observations were made (refer to the Site Photos (Appendix A) and Walkover Inspection Plan (Appendix B)):

- Main Road, 30m east of the building has undergone significant deformation due to the recent seismic events.
- The surface asphalt of the footpath leading toward the building has been severely cracked (up to 70mm wide) (Figures 1, 3 and 4).
- A lateral offset of up 300mm is evident between the asphalt and the concrete pad on the buildings eastern elevation (Figures 4 and 7).
- The asphalt paving on the eastern elevation appears to have settled up to 150mm relative to the foundations (Figure 4).
- An apparent tension crack (200mm deep and 150mm wide) extends from the south western corner of the building (Figure 6).
- A void underneath the concrete floor slab has been identified on the southern end of the east elevation (approximately 300mm wide, with an unknown length) (Figure 5).

4. Discussion

As a result of the 4th September 2010 to December 2011 Canterbury Earthquakes; ground damage has occurred to the Barnett Park Toilet building.

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

The building appears to be founded on a thick concrete floor slab which appears to have performed satisfactorily.

Severe ground shaking at this site has caused extensive cracking on the asphaltic footpaths. The asphalt footpaths leading to the toiled block are severely cracked, due to the induced movement, and have settled vertically by 150mm and displaced horizontally by up to 300mm.

Observations suggest that the ground surrounding the building has undergone liquefaction induced settlement and lateral spreading. This is inferred by the southwards lateral displacement of the ground along the eastern side of the building, the associated tension crack at the toe of the hill (approximately 150mm wide), the cracking of the footpath surface and the gap formed between the concrete floor slab and the surrounding footpath on the SE corner.

The cause of the void located beneath the concrete floor slab on the south eastern corner may be attributed to a localised area of sand which has settled due to the recent seismic events, which is consistent with the settlement of the surrounding footpath.

The Barnett Park Toilet block thick concrete foundations have performed satisfactorily during the recent seismic events. CCC would need to accept that damage may occur due to lateral spreading and differential settlement during future large earthquakes if the current foundations remain. This is likely to be low risk to life, but services are likely to be affected in future seismic events.

No site specific investigation results have been available for review at the time of reporting.

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

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 (Geonet) indicates there is currently a 13% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. Ground damage similar to what has been observed is anticipated in such an event, dependent on the location of the epicentre. It is expected that the probability of occurrence is likely to decrease with time, following periods of reduced seismic activity.

5. Recommendations

It is recommended that;

- The foundations are accepted based on the acceptance by the CCC that future land and services damage is likely to occur in future seismic events.

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.

Appendices:

Appendix A: Site Photographs

Appendix B: Land Zone Recovery, Site Location and Site Walkover Plans

Appendix C: Surrounding Site Investigation Data

Appendix A:
Site Photographs

Figure 1: Southern elevation of the Barnett Park Toilet building.

Figure 2: Eastern elevation of the Barnett Park Toilet Building.

Figure 3: Asphalt damage along the eastern side of the building.

Figure 4: Ground deformation on the south eastern corner of the building.

Figure 5: Void underneath the south eastern corner of the concrete floor slab.

Figure 6: Tension crack extending from the south western corner of the building.

Figure 7: the asphalt along the eastern side has been offset by approximately 300mm.

Appendix B:

Land Recovery Zone Plan
Site Location Plan
Site Walkover Plan

0m
100m
Approximate Scale: 1:1300 (A3)

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:	Barnett Park Toilet Geotechnical Desktop Study
Project No.:	6-QUCC1.13
Client:	Christchurch City Council

Land Recovery Zones

Drawn: Opus Geotechnical Engineer

Date: 19/06/2012

0 100m

Approximate Scale: 1:1000 (A3)

Key: ECan Borehole

BH	ECan Ref.
1	M36/8826
2	M36/8828
3	M36/8827
4	M36/9010
5	M36/8825

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: Barnett Park Toilet Block Geotechnical Desktop Study

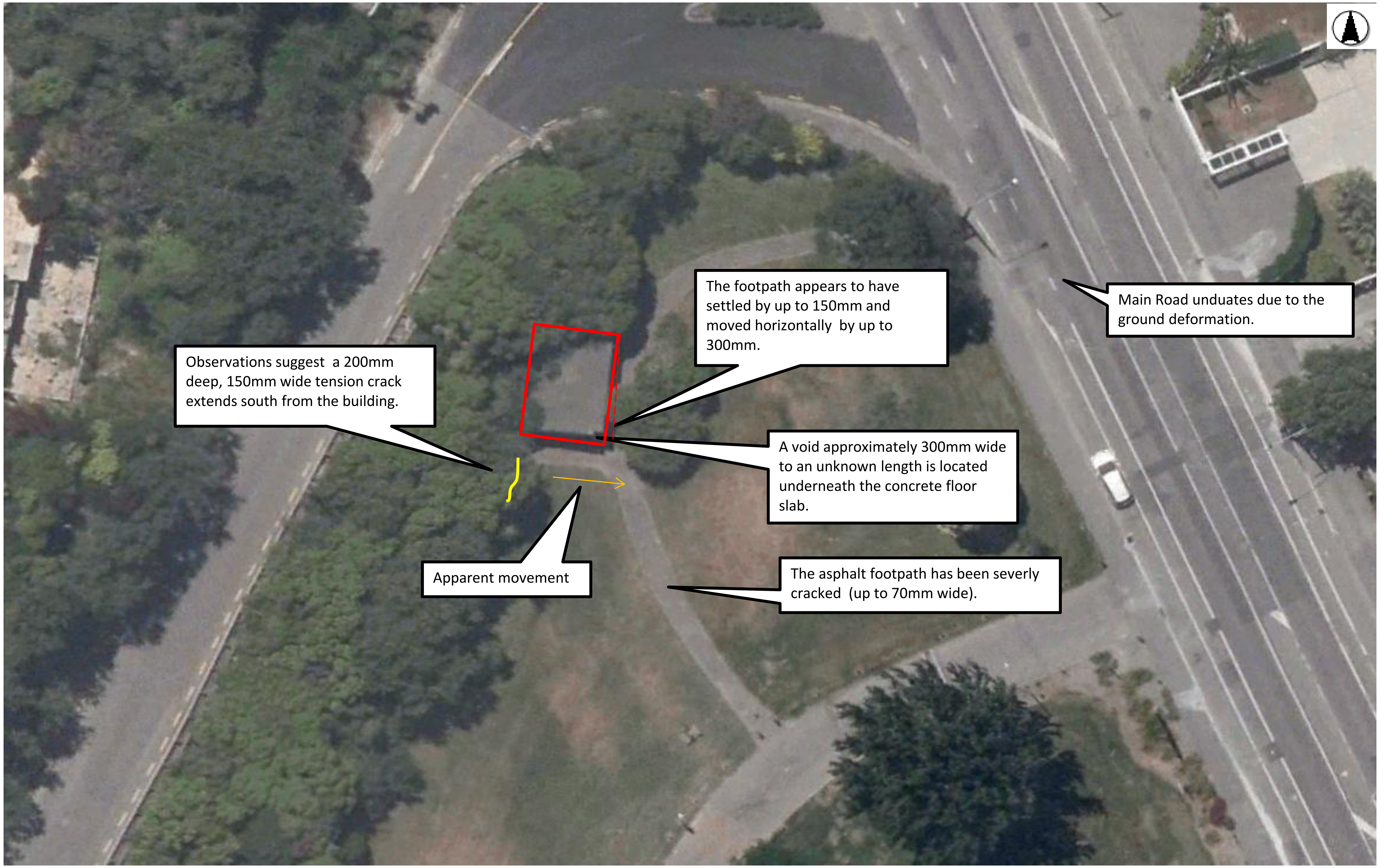
Project No: 6-QUCC1.13

Client: Christchurch City Council

Site Location Plan

Drawn: Opus Geotechnical Engineer

Date: 17 Septemeber 2012



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

Project: Barnett Park Toilet Block
Geotechnical Desk Study

Project No.: 6-QUCC1.13

Client: Christchurch City Council

Site Walkover Plan

Drawn: Opus Geotechnical Engineer

Date: 17 Septemeber 2012

Appendix C:
Surrounding Site Investigation Data

Borelog for well M36/8825

Gridref: M36:89055-38166 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 1.7 +MSD
Well name : CCC BorelogID 762
Drill Method : Not Recorded
Drill Depth : -4.5m Drill Date :

Environment Canterbury Regional Council

Depth(m)	Full Drillers Description	Formation Code
-0.30m	topsoil	
-0.91m	fine sand	
-1.22m	brown clay	
-1.65m	brown clay	
-2.13m	blue clayey silt	
-2.84m	coarse sand	
-3.20m	blue clayey silt	
-4.27m	sand	
-4.50m	coarse sand and shells	

Borelog for well M36/8826

Gridref: M36:89014-38243 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 1.7 +MSD
Well name : CCC BorelogID 763
Drill Method : Not Recorded
Drill Depth : -0.65m Drill Date : 12/02/1958

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.30m	road metal	
-0.2		-0.55m	bricks or concrete etc	
-0.4				
-0.6		-0.65m	boulders	

Borelog for well M36/8827

Gridref: M36:89040-38193 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 1.7 +MSD
Well name : CCC BorelogID 764
Drill Method : Not Recorded
Drill Depth : -3.3m Drill Date : 12/03/1958

Depth(m)	Full Drillers Description	Formation Code
-0.30m	topsoil	
-0.91m	coarse sand	
-1.52m	black coarse sand	
-1.67m	blue sandy silt and sand	
-1.83m	sandy silt	
-2.44m	black coarse sand with some shells	
-2.64m	black coarse sand	
-3.20m	black coarse sand	
-3.30m	running sand	

Borelog for well M36/8828

Gridref: M36:89026-38217 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 1.7 +MSD
Well name : CCC BorelogID 765
Drill Method : Not Recorded
Drill Depth : -3.15m Drill Date : 12/10/1958

Depth(m)	Full Drillers Description	Formation Code
-0.30m	road metal	
-1.35m	yellow coarse sand	
-1.67m	grey silt	
-3.05m	grey coarse sand	
-3.15m	running sand	

Scale(m): -0.2, -0.4, -0.6, -0.8, -1, -1.2, -1.4, -1.6, -1.8, -2, -2.2, -2.4, -2.6, -2.8, -3

Water Level

Borelog for well M36/9010

Gridref: M36:89058-38175 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 1.7 +MSD
Well name : CCC BorelogID 1847
Drill Method : Not Recorded
Drill Depth : -1.67m Drill Date : 1/01/1967

Depth(m)	Full Drillers Description	Formation Code
-0.15m	road metal	
-0.61m	gravel	
-1.30m	sand	
-1.67m	sandy silt	

Appendix D - CERA Report

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Barnett Park Toilets	Reviewer:	Will Parker
	Unit / No: 200 / Street: Main Rd	CPEng No:	144116
Building Address:	Barnett Park	Company:	Opus
Legal Description:		Company project number:	6--QUCCC.13
		Company phone number:	3635400
GPS south: (Degrees / Min / Sec)		Date of submission:	12/07/2014
GPS east:		Inspection Date:	Apr-12
		Revision:	Final
Building Unique Identifier (CCC):	PRK_1390_BLDG_002	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):	flat and low lying
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):	2.00

Building

No. of storeys above ground:	1	single storey = 1 / Ground floor elevation (Absolute) (m):	2.00
Ground floor split?	no	Ground floor elevation above ground (m):	0.15
Storeys below ground	0		
Foundation type:	strip footings	if Foundation type is other, describe:	
Building height (m):	2.70	height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	39		
Age of Building (years):	30	Date of design:	1976-1992
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):	toilets		
Importance level (to NZS1170.5):	IL2		

Gravity Structure

Gravity System:	load bearing walls		
Roof:	concrete	slab thickness (mm)	125
Floors:	concrete flat slab	slab thickness (mm)	125-150
Beams:			
Columns:	precast concrete	typical dimensions (mm x mm)	
Walls:	load bearing concrete	#N/A	

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	concrete shear wall		note total length of wall at ground (m):	7.8
Ductility assumed, μ:	1.00		wall thickness (m):	0.115
Period along:	0.20	##### enter height above at H31	estimate or calculation?	calculated
Total deflection (ULS) (mm):			estimate or calculation?	calculated
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	calculated
Lateral system across:	concrete shear wall		note total length of wall at ground (m):	5
Ductility assumed, μ:	1.00		wall thickness (m):	0.115
Period across:	0.20	##### enter height above at H31	estimate or calculation?	estimated
Total deflection (ULS) (mm):	50		estimate or calculation?	calculated
maximum interstorey deflection (ULS) (mm):	50		estimate or calculation?	calculated

Separations:

north (mm):		leave blank if not relevant
east (mm):		
south (mm):		
west (mm):		

Non-structural elements

Stairs:	
Wall cladding:	
Roof Cladding:	
Glazing:	
Ceilings:	
Services(list):	

Available documentation

Architectural	partial	original designer name/date	
Structural		original designer name/date	CCC, Project Number 562/1435, Drawing numbers A01 throug
Mechanical		original designer name/date	CCC, Project Number 562/1435, Drawing numbers A01 throug
Electrical		original designer name/date	
Geotech report	partial	original designer name/date	

Damage

Site: (refer DEE Table 4-2)

Site performance:	minor damage	Describe damage:	cracking to rc walls
Settlement:	25-100m	notes (if applicable):	settlement approximately 50mm
Differential settlement:	0-1:350	notes (if applicable):	cracking to asphalt pavement
Liquefaction:	none apparent	notes (if applicable):	building moved laterally
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	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:	yellow		
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	estimate
	Describe (summary):			
Across	Damage ratio:	0%		
	Describe (summary):			
Diaphragms	Damage?:		Describe:	
CSWs:	Damage?:		Describe:	
Pounding:	Damage?:		Describe:	
Non-structural:	Damage?:		Describe:	

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

Recommendations

Level of repair/strengthening required:	minor structural	Describe:	foundation and services
Building Consent required:		Describe:	Epoxy ejections into cracks
Interim occupancy recommendations:	partial occupancy	Describe:	

Along	Assessed %NBS before:	50%	##### %NBS from IEP below
	Assessed %NBS after:	50%	
Across	Assessed %NBS before:	50%	##### %NBS from IEP below
	Assessed %NBS after:	50%	

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