Garrick and Gilpin House
Botanic Gardens

PRK 1566 BLDG 015 EQ2

Detailed Engineering Evaluation

Quantitative Assessment Report

Garrick and Gilpin House
Detailed Engineering Evaluation

Quantitative Assessment Report

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Botanic Gardens - Garrick and Gilpin House
PRK 1566 BLDG 015 EQ2

Detailed Engineering Evaluation
Quantitative Report - SUMMARY
FINAL V2

Christchurch Botanical Gardens, Christchurch

Background

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

Key Damage Observed

Key damage observed includes:-

- There are signs of minor cracks to the concrete columns at the North West corner of Gilpin House.
- Within the door way between the two Houses there can been seen a crack in the concrete floor slab on the Gilpin House side of the division wall between the two houses.
- Externally on the North elevation a crack in the concrete side wall was noted to the West side of the column i.e. on Gilpin House side.
- On the same line on the South elevation a steel plate has been bolted across the junction in the basement concrete wall showing above ground level.

Critical Structural Weaknesses

The following critical structural weaknesses have been identified:

a) Unreinforced masonry infill panels subject to out-of-plane seismic forces.
b) Unreinforced masonry walls which are unrestrained subject to out-of-plane seismic forces.
c) Lateral stability at roof level in one direction is inadequate due to absence of a suitable bracing member at roof level required to transfer lateral loads at roof level to a suitable lateral load resisting element.

Indicative Building Strength (from quantitative assessment)

Based on the information available, and from undertaking a quantitative assessment,, the building's original capacity has been assessed to be less than 34% NBS and post-earthquake capacity to be less than 34% NBS. The building is therefore classed as an earthquake prone building. At the current state it is not recommended that the building is occupied.

Recommendations

It is recommended that:

a) It is recommended that the building not be occupied, given its earthquake prone building status and the elevated level of seismic risk in Christchurch.

b) A strengthening works scheme be developed to increase the seismic capacity of the building to at least 67% NBS, this will need to consider compliance with accessibility and fire requirements.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic evaluation of Garrick and Gilpin House, located in The Christchurch Botanic Gardens following the M6.3 Christchurch earthquake on 22 February 2011.

This report follows on from the qualitative assessment report produced in February 2012 which was undertaken to ascertain an initial capacity assessment using a desktop study. The results concluded that the building is potentially earthquake prone.

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

2 Compliance

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

2.1 Canterbury Earthquake Recovery Authority (CERA)

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

Section 38 – Works

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

Section 51 – Requiring Structural Survey

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

We understand that CERA 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.

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

2.2 Building Act

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

Section 112 - Alterations

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

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

Section 115 – Change of Use

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

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

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.

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 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.

<table>
<tr><th rowspan="2">Description</th><th rowspan="2">Grade</th><th rowspan="2">Risk</th><th rowspan="2">%NBS</th><th rowspan="2">Existing Building Structural Performance</th><th colspan="2">Improvement of Structural Performance</th></tr>
<tr><th>Legal Requirement</th><th>NZSEE Recommendation</th></tr>
<tr><td>Low Risk Building</td><td>A or B</td><td>Low</td><td>Above 67</td><td>Acceptable (improvement may be desirable)</td><td rowspan="2">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.</td><td>100%NBS desirable. Improvement should achieve at least 67%NBS</td></tr>
<tr><td>Moderate Risk Building</td><td>B or C</td><td>Moderate</td><td>34 to 66</td><td>Acceptable legally. Improvement recommended</td><td>Not recommended. Acceptable only in exceptional circumstances</td></tr>
<tr><td>High Risk Building</td><td>D or E</td><td>High</td><td>33 or lower</td><td>Unacceptable (Improvement required under Act)</td><td>Unacceptable</td><td>Unacceptable</td></tr>
</table>

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[i] 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, 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/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.

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

4 Background Information

4.1 Building Description

From information issued by Christchurch City Council in their flyer about the Botanic Garden Conservatories, Gilpin House is stated as being constructed in 1954 and Garrick House was completed in 1957 to serve as a tropical glasshouse for the Hagley Park Botanic Gardens. However, on the CCC web site Gilpin House is quoted as being built in the 1960's with Garrick House constructed in the 1950's. From site inspections it would appear that Gilpin House is an extension on the end of Garrick House and therefore we consider that it is more likely that Garrick House was constructed first with Gilpin as an extension. The buildings are located in Hagley Park within the Botanic Gardens (see *Figure 2* below).

Access to the building is via double doors and ramp from Townend House through a flat roofed link structure into the East end of Garrick House. A single door in the division wall allows access into Gilpin House with a further single door in the West end of Gilpin House leading out onto a flight of steps down to ground level.

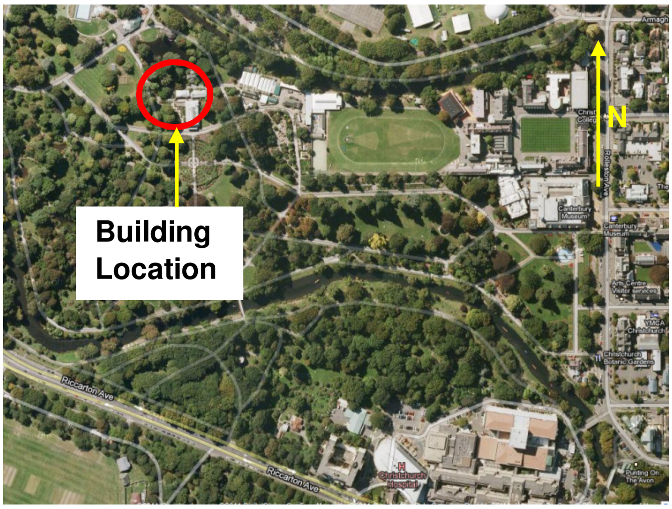


Figure 2: Site location plan

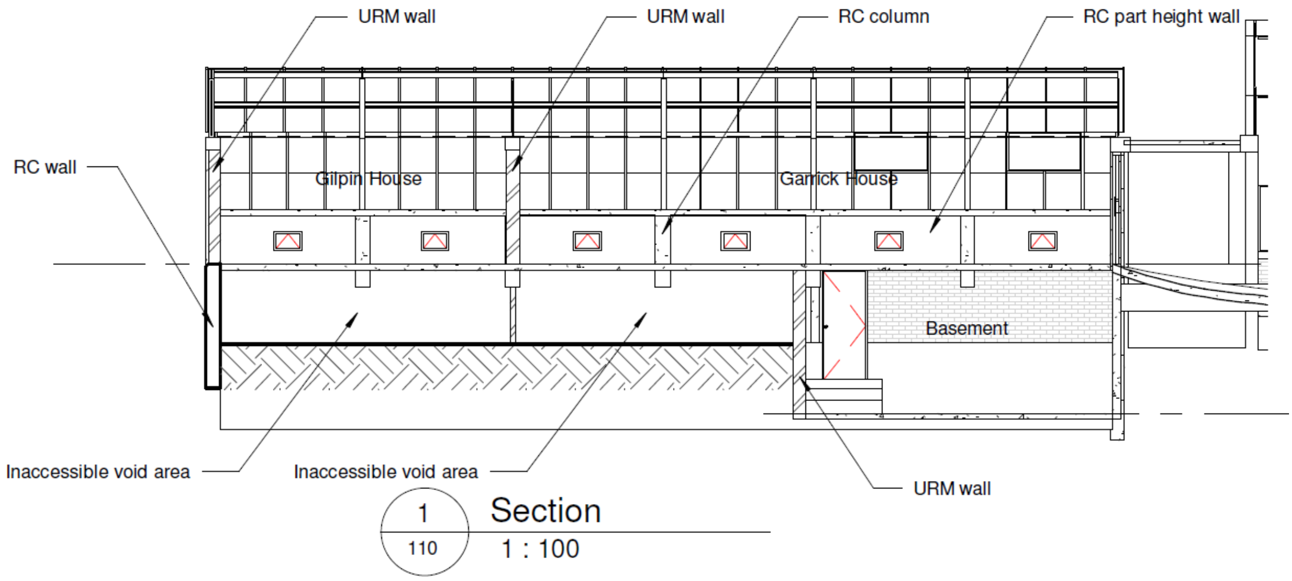
The super-structure consists of two distinct parts; the lower reinforced concrete frame with concrete retaining walls, masonry honeycomb perimeter walls and then a glazed asymmetrical steel portal framed roof sat on masonry and concrete walls.

Internally there is a masonry division wall between the two conservatories. Beneath the floor are two basement areas, one accessible at the West end under Garrick and another within the central area. The Western Gilpin floor area appears to have no void beneath.

There is a masonry chimney adjacent the South elevation of Garrick House which serves the boiler within the basement area. On top of the masonry is a further steel flue which increases the height of the chimney and is stabilised by guy wires down to adjacent structures

No inspection of the foundations has been carried out however; it has been assumed for this small structure that simple spread foundations have been provided close to the surface.

4.2 Gravity load resisting system



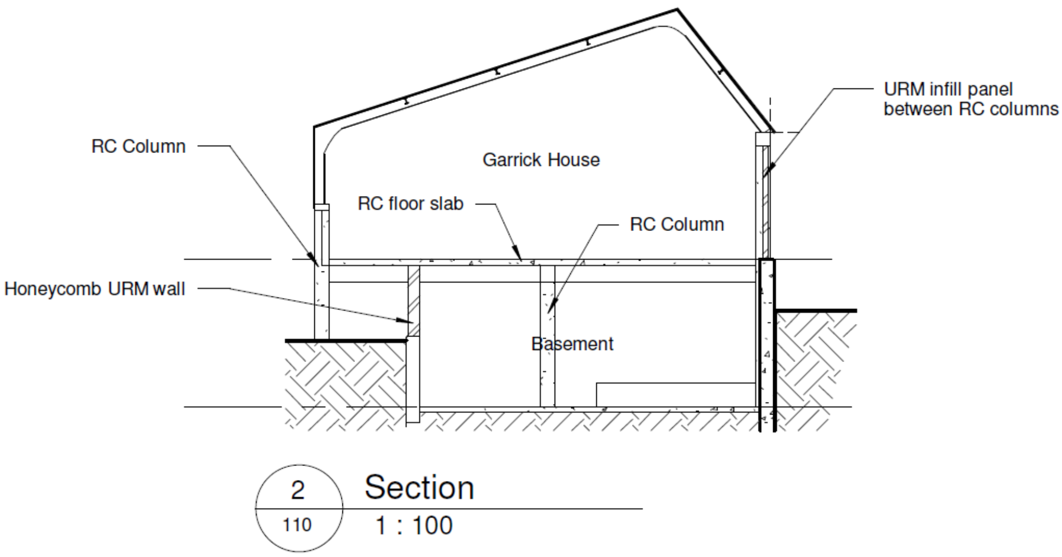
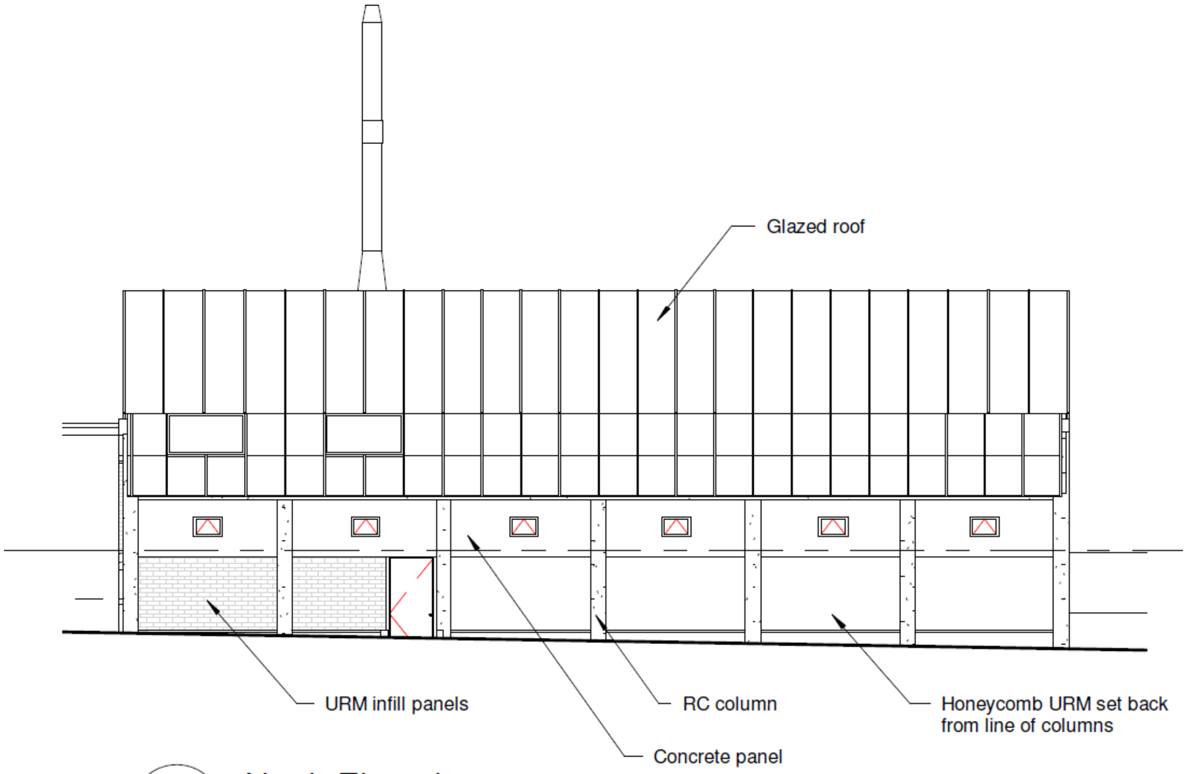
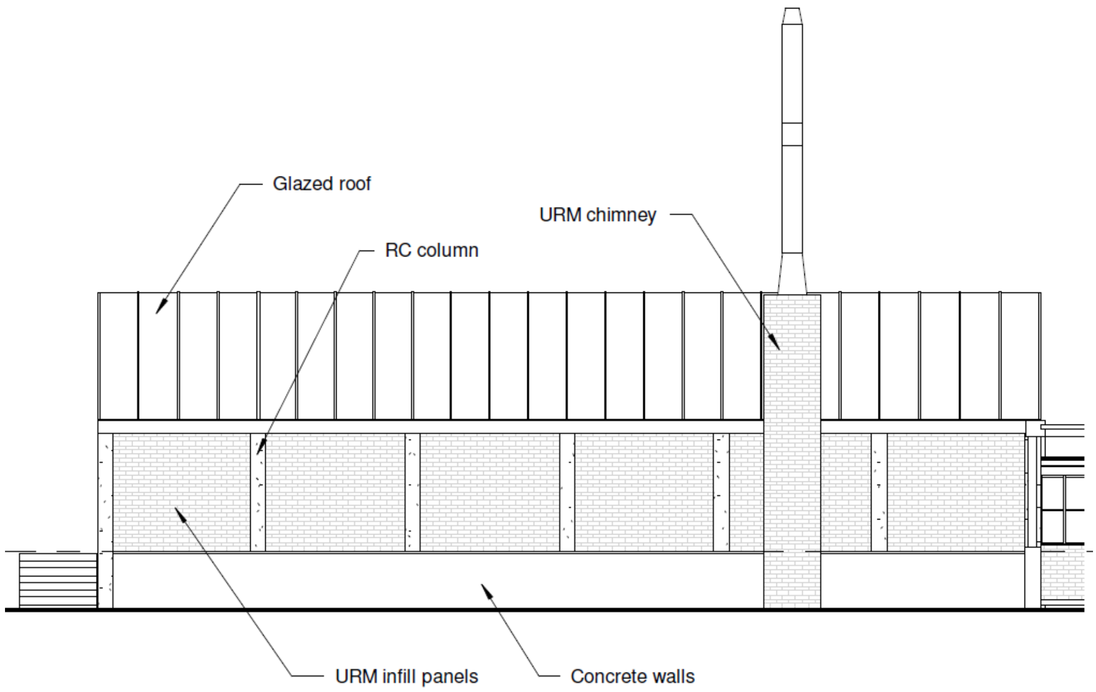


Figure 3: Sections through the Garrick and Gilpin House building



1 / 100 North Elevation
1 : 100



1 / 100 South Elevation
1 : 100

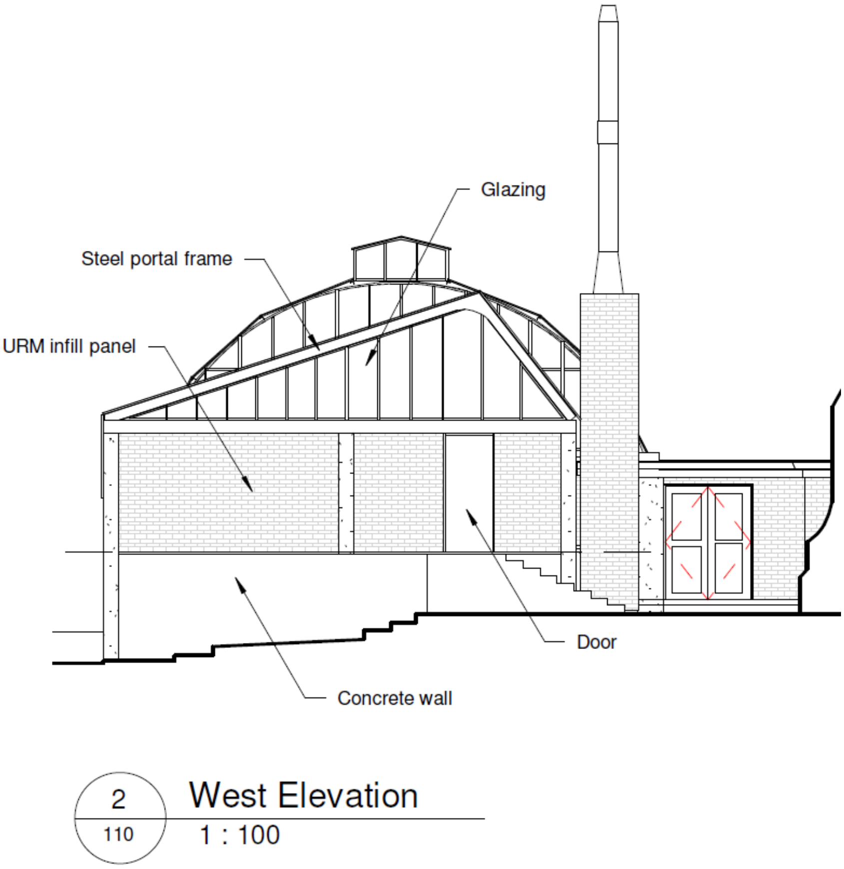


Figure 4: Elevations of the Garrick and Gilpin House building

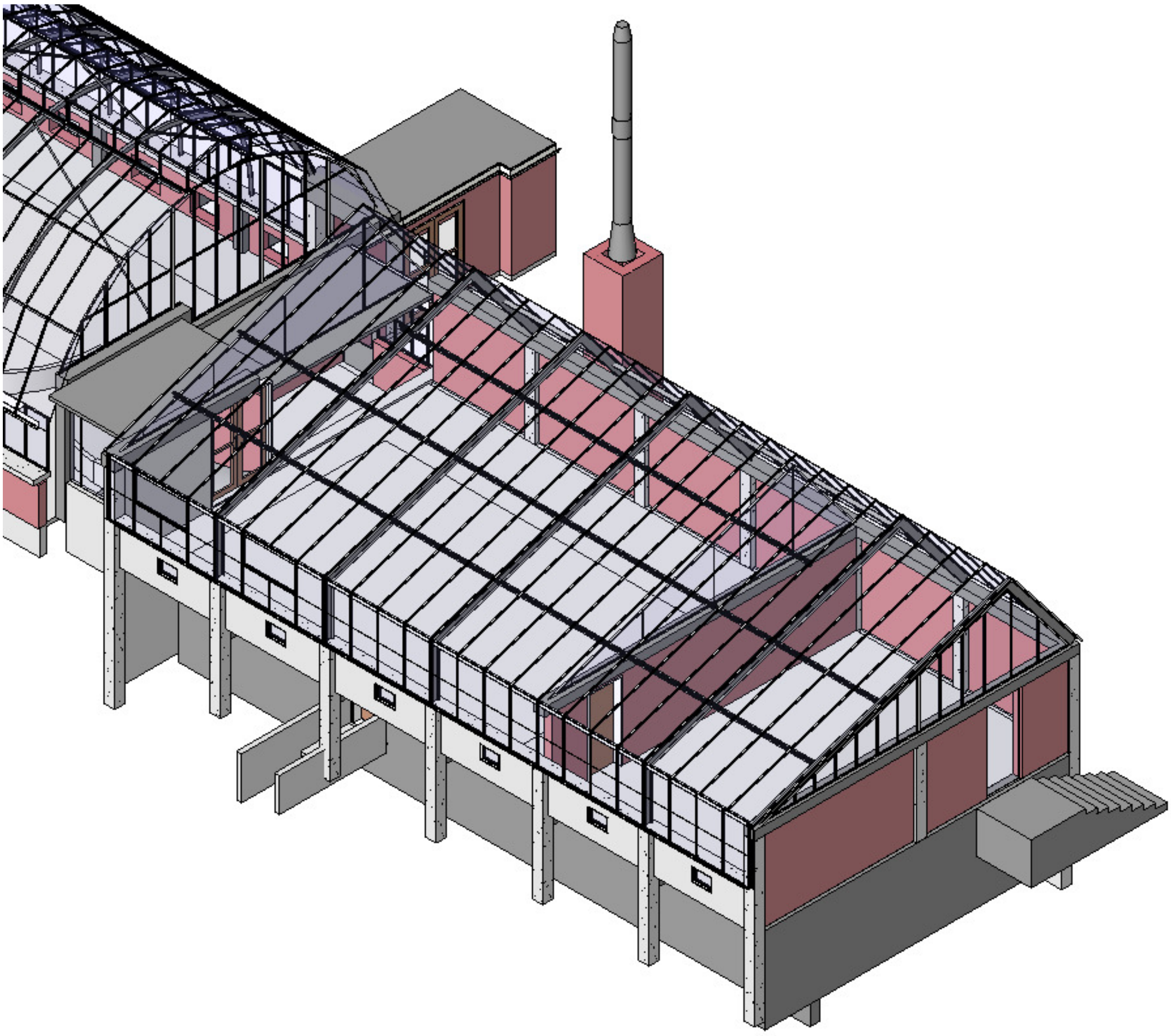


Figure 5: 3D view of the Garrick and Gilpin House building

The glass is supported by steel channel section purlins spanning between the portal frames

Light steel fabricated asymmetrical portal frames are set at regular centres supporting the roof connected to concrete beam and column wall with infill masonry to the South wall and a low level concrete wall on the North wall.

Loads from the steel frames are transmitted to the concrete columns through bolted pinned connections to the reinforced concrete beams.

Vertical loads are transmitted to the ground from the roof through the concrete columns to the foundations. The concrete floor spans two-way to a grid of concrete beams which in turn span to the column positions or the concrete basement retaining walls.

Concrete spread foundations transmit the loads to the ground. The size and type of foundations are not known and no investigation of the existing footings has been carried out.

4.3 Seismic Load Resisting System

Longitudinal – East to West Direction

- Horizontal loads imposed on the roof structure are transferred through some diaphragm action through the glass roof, however this relies on the glass itself and its fixing detail. There is an inclined brace at the East end of the roof from the portal rafter down to the end wall, *[see photograph 1]*. There appeared to be no equivalent brace at the West end of the building.
- The South wall transfers the longitudinal loads to the basement walls and hence foundations by shear wall action.
- Within the short glazed wall section of the North wall there is no bracing so frame action transfers the horizontal load to the top of the concrete side walls. Below this the forces are transferred into the columns and then through frame action down to the foundations.
- The honeycomb brickwork wall to the basement to the North side is set back under the building and as such is not on the line of the columns. It is therefore considered that this masonry will not contribute to the longitudinal resistance of the sub floor structure.

Lateral – North to South direction

- The portal frames of the roof transfers the load to the top of the North and South walls at concrete column positions. The columns cantilever up from the floor and transfer the lateral loads by this frame action to the insitu concrete floor slab.
- The concrete floor slab and down stand beams act as a stiff diaphragm transferring the lateral loads to the basement walls.
- The basement walls then transfer the loads to the foundations by shear action.

4.4 Survey

4.4.1 Post 22 February 2011 Rapid Assessment

A structural (Level 2) assessment of the building was carried out on 9th March 2011 by Opus International Consultants Limited. These inspections included external and internal visual inspections of all the structural elements only, without the benefit of any opening up works.

4.4.2 Further Inspections

A damage survey was conducted in November 2011 by Opus International Consultants Limited, refer to section 5 and Appendix A (photographs) of the Qualitative Report.

4.5 Original Documentation

Drawings of the structure were not made available.

5 Damage Assessment

The following damage has been noted:

5.1 Surrounding Buildings

No damage to buildings within immediate proximity

5.2 Residual Displacements

No evidence of ground damage or surface expression of liquefaction was visible in the immediate vicinity of the building, and no surface expression was observed elsewhere on the site. No signs of settlement have been observed in the floor or walls of the building. This is consistent with the observations of adjacent buildings.

5.3 Foundations

The form and depth of the foundations is unknown, however it is expected that the building is supported on shallow concrete strip footings which are assumed to be undamaged.

5.4 Primary Gravity Structure

There are signs of minor cracks to the concrete columns at the North West corner of Gilpin House.

Within the door way between the two Houses there can been seen a crack in the concrete floor slab on the Gilpin House side of the division wall, *[see photograph 3]*. Externally on the North elevation a crack in the concrete side wall was noted to the West side of the column i.e. on Gilpin House side, *see photograph 4].* On the same line on the South elevation a steel plate has been bolted across the junction in the basement concrete wall showing above ground level, *[see photograph 5]*.

5.5 Masonry Chimney

The masonry chimney adjacent the South elevation of Garrick House appears to have been strengthened in the past with the provision of a steel collar at the top of the brickwork. Attached to this collar at each corner are four tensioning rods which are assumed to be anchored into foundations below ground and tensioned to compress the masonry and aid its lateral stability. On top of the masonry is a further steel flue which increases the height of the chimney. This steel chimney section is stabilised by guy wires down to adjacent structures, see photo 6. Apart from some deterioration of the brickwork from weathering there did not appear to be any cracking due to movement of the chimney.

6 General Observations

The general condition of the building appears to be reasonable considering the age. There are signs of minor historic cracking to the concrete structure in a number of locations.

7 Detailed Seismic Assessment

The detailed seismic assessment has been based on the NZSEE 2006 [2] guidelines for the "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" together with the "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure" [3] draft document prepared by the Engineering Advisory Group on 19 July 2011.

7.1 Critical Structural Weaknesses

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 a building. During the initial qualitative stage of the assessment the following potential CSW's were identified for the building and have been considered in the quantitative analysis.

a) Unreinforced masonry infill panels subject to out-of-plane seismic forces.

b) Unreinforced masonry walls which are unrestrained subject to out-of-plane seismic forces.

c) Lateral stability at roof level in one direction is inadequate due to absence of a suitable bracing member at roof level required to transfer lateral loads at roof level to a suitable lateral load resisting element.

7.2 Quantitative Assessment Methodology

The assessment assumptions and methodology have been included in Appendix 2 of the report due to the technical nature of the content. A brief summary follows:

In-plane models of the frames forming the super-structure were created along with a 3D model of the supporting concrete with brick infill structure. An assessment of the building capacities was made based on the actions determined by equivalent static forces established from NZS1170.5, with an updated Z factor of 0.3 (B1/VM1).

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

7.4 Quantitative Assessment

A summary of the structural performance of the building is shown in the following tables. 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 elements.

Table 3: Summary of Seismic Performance – Garrick and Gilpin House

Structural Element/System	Failure mode, or description of limiting criteria based on elastic capacity of critical element.	Critical Structural Weakness and Collapse Hazard	% NBS based on calculated capacity (ULS)
RC columns above ground level.	Flexure. Ductility factor, μ = 2.	No	76%
RC Frame with brick infill, in-plane	In-plane capacity governed by shear and strut capacity of brick infill panels.	No	>100%
URM infill to RC Frame , out-of-plane	Out-of-plane capacity governed by slenderness of the infill masonry wall.	Yes	49%
Unrestrained URM walls	Out-of-plane capacity governed by slenderness.	Yes	51%
RC frame with URM infill, out-of-plane	Flexure. Ductility factor, μ = 1.25.	No	74%
RC shear walls between basement and ground floor	Shear capacity. Ductility factor, μ = 1.25.	No	>100%
RC walls at ground floor level	Shear capacity. Ductility factor, μ = 1.25.	No	>100%

Structural Element/System	Failure mode, or description of limiting criteria based on elastic capacity of critical element.	Critical Structural Weakness and Collapse Hazard	% NBS based on calculated capacity (ULS)
Roof bracing	Lateral stability of frames above wall level. This is a tension only system which acts in one direction only of which it has been assessed there is a capacity of 67%. The value of less than 33% has been given as the transfer of lateral loads in the opposite direction is reliant on the compression of steel purlins which are not designed for this purpose.	Yes	<33%
Transverse steel portal frames at roof level	Flexure. Ductility factor, μ = 2.	No	67%
URM chimney structure	In-plane shear and overturning stability. The URM has been evaluated as a “low risk” structure provided there is adequate tension provided in the historic remedial strengthening. The guy wires and tension rods should be checked periodically to ensure that they are well tensioned.	No	>67%

7.5 Discussion of results

The assessment results indicate that the unreinforced masonry wall elements of the building should be classified as “moderate risk.” The building stability relies upon the unreinforced masonry infill panels above ground floor level. The out-of-plane resistance of these walls was found to be less than 67%. The unrestrained URM walls were also found to be less than 67% and are therefore also at “moderate risk” of collapse.

The tie rods which are holding the chimney down and the guy wires supporting the steel flue should be checked periodically to ensure that there is adequate tension. An assessment has been made to determine if the tension in these historic remedial strengthening elements are likely to have sufficient tensile capacity required to resist both overturning and for in-plane seismic forces. This assessment is based on the assumption that the tie rods are a minimum of 20mm in diameter and of high yield strength steel (460MPa). This should be confirmed. The tension rods will have adequate capacity if the assumed values are found to be correct.

The building capacity is less than 34% NBS so it is therefore classed as an earthquake prone building in accordance with the Building Act 2004. As this also results in the building being classed as a dangerous building it is recommended that the CCC review the occupancy of this building in its current state.

8 Summary of Geotechnical Appraisal

The building is located in an area that is assessed to have shallow gravels and low risk of liquefaction. Further investigations are recommended to be undertaken at design stage to assess the risk of liquefaction and mitigation measures if the building is to be strengthened.

9 Remedial Options

The assessment has identified critical elements which are at "moderate risk" of failure. It is therefore recommended that the building is improved by increasing the seismic performance to as near as practicable to 100%NBS, and at least 67%NBS. Our conceptual strengthening scheme to achieve this would include:

a) Provision for a more robust load path between the roof structure and the front/rear walls.

b) Addressing the out of plane capacity of the unreinforced masonry walls.

10 Conclusions

a) The seismic performance of the building is rated at less than 34% NBS as governed by the lateral stability of the building at roof level.

b) The current seismic rating of the building is less than 34% NBS of the current building code for an Importance Level 2 structure. Therefore the building is considered to be earthquake prone and improvement works are required to meet the legal requirements of the current building code.

c) The building should be strengthened to achieve a seismic capacity of at least 67% NBS.

d) As the capacity of the building is less than 34% NBS it is automatically considered a dangerous structure. Therefore the Christchurch City Council should review the occupancy restrictions of the building.

11 Recommendations

a) It is recommended that the building not be occupied, given its structural weaknesses and the elevated level of seismic risk in Christchurch.

b) A strengthening works scheme be developed to increase the seismic capacity of the building to at least 67% NBS, this will need to consider compliance with accessibility and fire requirements.

12 Limitations

a) This report is based on an inspection of the structure of the buildings and focuses on the structural damage resulting from the 22 February Canterbury Earthquake 2011 and aftershocks only. Some structural damage is described but this is not intended to be a complete list of damage to 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 this time.

c) This report is prepared for CCC to assist with assessing the 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] NZSEE, *Assessment and Improvement of Unreinforced Masonry Buildings for Earthquake Resistance*, Draft prepared by The University of Auckland, February 2011.

Appendix 1 - Photographs

Garrick and Gilpin House, Botanic Gardens, Christchurch		
No.	**Item description**	**Photo**
	<u>General</u>	
1.	Tie rod at east end of the building.	

2.	URM chimney with apparent seismic retrofit.	
3.	Concrete floor slab at junction between Garrick & Gilpin house.	

4.	Steel plate at junction between Garrick & Gilpin house.	

Appendix 2 – Quantitative assessment methodology and assumptions

Quantitative Assessment

Methodology and Assumptions

1.1. Material Strength

Structural drawings were not available, the following material strengths were assumed:

Structural steel – f_y = 270 MPa

Concrete – f'_c = 30 MPa

1.2. Building Weights

Roof/glazing – 1.00 kPa

Density of masonry – 21 kN/m^3

Dead load of floor - self-weight of the slab + 50% 3.00kPa planting.

Imposed load of floor – 50% 3.00kPa

1.3. Seismic Parameters

T (estimated) = 0.40 sec (for walls)

Z = 0.30

Importance Level 2

R = 1.0

N(T,D) = 1.0

Site subsoil class = D

μ = 2 for transverse steel portal frames and rocking check

μ = 1.25 for structural walls

1.4. Analysis Procedure

Hand calculation was used to estimate the force distribution between the walls in plane in both lateral and transverse direction. Force has been distributed based on the relative size of each wall section. Between basement and ground floor level, the reinforced concrete slab is assumed to be stiff enough to act as a diaphragm. Forces are therefore distributed evenly at this level according to their relative size. However, between ground floor and roof there is no diaphragm to distribute the forces between walls at this level. Walls are therefore assessed as attracting local loads only.

It has been assumed for the purpose of this report that the connection between the Garrick and Gilpin House is strong enough for the building to act as one building.

Unrestrained URM is judged to not contribute to the resistance of the building.

The steel transverse portal frames are modelled with pinned bases where they are connected to the RC columns. The supporting columns are assumed to have pinned bases and a continuous connection at first floor level.

Appendix 3 – CERA DEEP data sheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Gilpin-Garrick (Ground-Roof)	Reviewer:	Robert Davey
	Unit / No: / Street	CPEng No:	
Building Address:	Botanic Gardens, Christchurch	Company:	Opus International Consultants Ltd
Legal Description:		Company project number:	6-QUCCC.40
		Company phone number:	+64 3 363 5400
	Degrees / Min / Sec		
GPS south:	43 / 31 / 47.04	Date of submission:	1/02/2013
GPS east:	172 / 37 / 14.84	Inspection Date:	1-Nov-11
		Revision:	Final V2
Building Unique Identifier (CCC):	PRK_1566_BLDG_015 EQ2	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:	gravel	Soil Profile (if available):	Unknown
Site Class (to NZS1170.5):	D		
Proximity to waterway (m, if <100m):	50	If Ground improvement on site, describe:	
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	6.00

Building

No. of storeys above ground:	1 (single storey = 1)	Ground floor elevation (Absolute) (m):	6.00
Ground floor split?	no	Ground floor elevation above ground (m):	0.00
Storeys below ground	1		
Foundation type:	other (describe)	if Foundation type is other, describe:	Assumed concrete strip footings
Building height (m):	7.00	height from ground to level of uppermost seismic mass (for IEP only) (m):	6
Floor footprint area (approx):	200		
Age of Building (years):	58	Date of design:	1935-1965
Strengthening present?	no	If so, when (year)?	
		And what load level (%g)?	
Use (ground floor):	public	Brief strengthening description:	
Use (upper floors):	public		
Use notes (if required):			
Importance level (to NZS1170.5):	IL2		

Gravity Structure

Gravity System:	frame system		
Roof:	steel framed	rafter type, purlin type and cladding	channel purlins, glazed
Floors:	other (note)	describe sytem	insitu concrete beam and slab
Beams:	cast-insitu concrete	overall depth x width (mm x mm)	
Columns:	cast-insitu concrete	typical dimensions (mm x mm)	
Walls:	load bearing brick	#N/A	

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	other (note)		describe system	Roof bracing(incomplete) down to mixture of infill URM walls and concrete shear walls
Ductility assumed, μ:	1.25			
Period along:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	other (note)		describe system	Moment frames
Ductility assumed, μ:	1.25			
Period across:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

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

Non-structural elements

Stairs:	other (specify)	describe	None
Wall cladding:	exposed structure	describe	brick/glazing
Roof Cladding:	Other (specify)	describe	glazing
Glazing:	steel frames		
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	none	original designer name/date	

Damage

Site: (refer DEE Table 4-2)

Site performance:	Good	Describe damage:	None observed
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

Current Placard Status: green

Along — Damage ratio: 0% — Describe how damage ratio arrived at:

Describe (summary): No apparent structural damage, however roof brace "missing"

Across — Damage ratio: 0%

Describe (summary): No apparent structural damage

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

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

Recommendations

Level of repair/strengthening required:	minor structural	Describe:	Remediate roof bracing. Improve out of plane resistance
Building Consent required:	yes	Describe:	
Interim occupancy recommendations:	do not occupy	Describe:	

Along	Assessed %NBS before:	32%	0% %NBS from IEP below
	Assessed %NBS after:	32%	
Across	Assessed %NBS before:	67%	0% %NBS from IEP below
	Assessed %NBS after:	67%	

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Gilpin-Garrick (Basement-Ground)	Reviewer:	Robert Davey
	Unit / No: / Street	CPEng No:	
Building Address:	Botanic Gardens, Christchurch	Company:	Opus International Consultants Ltd
Legal Description:		Company project number:	6-QUCCC.40
		Company phone number:	+64 3 363 5400
	Degrees / Min / Sec		
GPS south:	43 / 31 / 47.04	Date of submission:	1/02/2013
GPS east:	172 / 37 / 14.84	Inspection Date:	1-Nov-11
		Revision:	Final V2
Building Unique Identifier (CCC):	PRK_1566_BLDG_015 EQ2	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:	gravel	Soil Profile (if available):	Unknown
Site Class (to NZS1170.5):	D		
Proximity to waterway (m, if <100m):	50	If Ground improvement on site, describe:	
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	6.00

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	6.00
Ground floor split?	no		Ground floor elevation above ground (m):	0.00
Storeys below ground	1			
Foundation type:	other (describe)		if Foundation type is other, describe:	Assumed concrete strip footings
Building height (m):	7.00		height from ground to level of uppermost seismic mass (for IEP only) (m):	6
Floor footprint area (approx):	200			
Age of Building (years):	58		Date of design:	1935-1965
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	public		Brief strengthening description:	
Use (upper floors):	public			
Use notes (if required):				
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	frame system		
Roof:	steel framed	rafter type, purlin type and cladding	channel purlins, glazed
Floors:	other (note)	describe sytem	insitu concrete beam and slab
Beams:	cast-insitu concrete	overall depth x width (mm x mm)	
Columns:	cast-insitu concrete	typical dimensions (mm x mm)	
Walls:	load bearing brick	#N/A	

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	other (note)		describe system	Diaphragm floor distributes to mixture of infill URM walls and concrete shear walls
Ductility assumed, μ:	1.25			
Period along:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	other (note)		describe system	Diaphragm floor distributes to mixture of infill URM walls and concrete shear walls
Ductility assumed, μ:	1.25			
Period across:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

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

Non-structural elements

Stairs:	other (specify)	describe	None
Wall cladding:	exposed structure	describe	brick/glazing
Roof Cladding:	Other (specify)	describe	glazing
Glazing:	steel frames		
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	none	original designer name/date	

Damage

Site: (refer DEE Table 4-2)

Site performance:	Good	Describe damage:	None observed
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:	green		
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	
	Describe (summary):	No apparent structural damage		
Across	Damage ratio:	0%		
	Describe (summary):	No apparent structural damage		
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	no	Describe:	

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

Recommendations

	Level of repair/strengthening required:	none	Describe:	
	Building Consent required:	yes	Describe:	
	Interim occupancy recommendations:	do not occupy	Describe:	
Along	Assessed %NBS before:	100%	0% %NBS from IEP below	
	Assessed %NBS after:	100%		
Across	Assessed %NBS before:	100%	0% %NBS from IEP below	
	Assessed %NBS after:	100%		

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