



Yaldhurst Domain Tennis Pavilion
PRK 1642 BLDG 002 EQ2
Detailed Engineering Evaluation
Quantitative Report
Christchurch City Council



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Yaldhurst Domain Tennis Pavilion

Detailed Engineering Evaluation Quantitative Report

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Quantitative Report
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Background

This is a summary of the quantitative report for the Yaldhurst Domain Tennis Pavilion and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group, visual inspections and measurements taken during August 2012, and calculations.

Critical Structural Weaknesses

No critical structural weaknesses have been identified for this structure.

Indicative Structure Strength

Based on the information available, and from undertaking a quantitative assessment, the original capacity of the building has been assessed as approximately 58% NBS, and therefore is considered an earthquake risk building.

Due to the lightweight structure and the inherently ductile nature of the nailed timber bracing, we do not believe this structure poses a collapse risk and is suitable for continued occupancy.

Recommendations

It is recommended that the following be undertaken:

- (a) That the bracing capacity of the wall linings be addressed to increase the seismic capacity to at least 67% NBS.
- (b) That the front canopy roof plane be braced or strengthened.
- (c) Intrusive investigations be undertaken to determine the capacity of the foundations.

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1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Yaldhurst Domain Tennis Pavilion, Christchurch. This report was commissioned following the M6.3 Christchurch earthquake on 22 February 2011.

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

The seismic assessment and reporting have been undertaken based on a quantitative procedure detailed in Opus document 'Guidelines for Detailed Engineering Evaluation of Timber Framed Buildings', referencing NZS 1170.5 – Structural Design Actions.

2 Compliance

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

2.1 Canterbury Earthquake Recovery Authority (CERA)

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

Section 38 – Works

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

Section 51 – Requiring Structural Survey

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

We understand that CERA requires a detailed engineering evaluation to be carried out for all buildings (other than those exempt from the Earthquake Prone Building definition in the Building Act). CERA has adopted the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011. This document sets out a methodology for both initial qualitative and detailed quantitative assessments.

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

1. The importance level and occupancy of the building.

2. The placard status and amount of damage.
3. The age and structural type of the building.
4. Consideration of any critical structural weaknesses.

Any building with a capacity of less than 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) is satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'.

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

Section 121 – Dangerous Buildings

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

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

Section 122 – Earthquake Prone Buildings (EPB)

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

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

Section 124 – Powers of Territorial Authorities

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

Section 131 – Earthquake Prone Building Policy

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

2.3 Christchurch City Council Policy

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

The 2010 amendment includes the following:

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

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

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

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

2.4 Building Code

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

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

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

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

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

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

- 1.1 *Giving priority to the safety and well-being of the community and having regard to this principle in assessing obligations to clients, employers and colleagues.*
- 1.2 *Ensuring that reasonable steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.*

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

3 Earthquake Resistance Standards

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

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

Description	Grade	Risk	% NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34% NBS.	100% NBS desirable. Improvement should achieve at least 67% NBS
Moderate Risk Building	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). 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 Order¹ in Council 16 September 2010, modified the meaning of ‘dangerous building’ to include buildings that were identified as being Earthquake Prone Buildings (EPB). Such a building would be issued with a Section 124 notice by the Territorial Authority, or CERA acting on their behalf, once they are

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

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

3.1.2 Cordoning

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

3.1.3 Strengthening

- Industry guidelines (NZSEE 2006 [2]) strongly recommend that every effort be made to achieve improvement to at least 67% NBS. A strengthening solution to anything less than 67% NBS would not provide an adequate reduction to the level of risk.
- It should be noted that full compliance with the current building code requires building strength of 100% NBS.

3.1.4 Our Ethical Obligation

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

4 Building Description

4.1 General

The building is a single storey timber framed structure with a timber framed roof. The building floor appears to be a concrete slab. We lack foundation detail, but consider it likely that if the floor is concrete, it would have a perimeter beam and possibly thickening under load bearing walls.

The building is situated on a flat section and is approximately 9.5m long and 3.75m wide. The apex of the roof is approximately 3.5m above the ground and the building has a wall height of approximately 2.6m.

The roof is extended 1.8m beyond the front face of the building to provide a canopy over a concrete slab. This extended roof is supported on timber posts and a standalone wall that forms a windbreak at one end.

We have no information on when the structure was constructed.

4.2 Gravity Load Resisting System

The building is timber framed with external wall cladding of weatherboard. The social room has internal wall cladding of vertical tongue and groove timber and a lightweight ceiling lining. The store rooms have no internal wall or ceiling linings.

The roof is timber framed with vertical timber planking to the interior, and the external cladding is corrugated iron. The roof is extended along the frontage to form a canopy.

We believe that the building is constructed in general accordance with NZS 1900: Chapter 6.1:1964.

4.3 Seismic Load Resisting System

Lateral resistance for the structure is likely provided in the social room from the vertical tongue and groove internal lining. The presence of any cut-in diagonal timber bracing could not be confirmed without intrusive investigation. The store rooms have no diagonal bracing and are reliant on the limited bracing capacity provided by the weatherboard.

The roof front extension has no roof plane bracing to effectively transfer roof loadings back to the building front wall.

5 Building Survey

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

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

The building inspection identified deterioration of several timber members due to rot and the presence of common house borer.

6 Geotechnical Appraisal

Due to a lack of observed ground damage at the site, a geotechnical assessment was not carried out.

7 Detailed Seismic Assessment

7.1 Seismic Coefficient Parameters

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

- Site soil class D, clause 3.1.3 NZS 1170.5:2004
- Site hazard factor, $Z=0.3$, B1/VM1 clause 2.2.14B
- Return period factor $R_u = 1.0$ from Table 3.5, NZS 1170.5:2004, for an Importance Level 2 structure with a 50 year design life.
- Ductility factor $\mu_{max} = 2.0$ (Pre-1978 timber framed building).

7.2 Detailed Seismic Assessment Results

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

Table 2: Summary of Seismic Performance

Structural Element/System	Failure mode and description of limiting criteria	% NBS based on calculated capacity
Transverse direction, tongue and groove timber linings and weatherboard	Bracing capacity of the walls	58%
Longitudinal direction, tongue and groove timber linings and weatherboard.	Bracing capacity of the walls	80%

7.3 Discussion of Results

As shown in Table 2 above, bracing elements used for analysis were the tongue and groove timber linings and weatherboard. Allowing for a minimum length of 1.2m, 20 BU/m was used for analysis. (Ref: NZSEE 2011).

The structure has a calculated capacity of approximately 58% NBS. This is above the threshold limit for structures classified as 'Earthquake Prone' which is one third (33%) of the seismic performance specified in the current loading standard for new structures (New Building Standard, or NBS). The structure is therefore classed as being a moderate earthquake risk in accordance with the NZSEE guidelines.

No critical structural weaknesses (CSW) were found for this structure.

Due to the lightweight structure and the inherently ductile nature of the nailed timber bracing, we do not believe this structure poses a collapse risk and is suitable for continued occupancy.

7.4 Limitations and Assumptions in Results

Our analysis and assessment is based on an assessment of the structure in its undamaged state.

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

- simplifications made in the analysis, including boundary conditions such as foundation fixity;
- assessments of material strengths based on limited drawings, specifications and site inspections;
- the normal variation in material properties which change from batch to batch; and
- without an intrusive investigation the capacity of the foundation cannot be determined, however, due to the small loads being imparted on them, it is assumed that their capacity is greater than 67% NBS.

8 Conclusions

- (a) The structure has a seismic capacity of approximately 58% NBS and therefore is a moderate earthquake risk.
- (b) The seismic capacity is governed by the bracing capacity of the walls and roof plane.
- (c) Due to the lightweight structure and the inherently ductile nature of the nailed timber bracing, we do not believe this structure poses a collapse risk and is suitable for continued occupancy.

9 Recommendations

It is recommended that the following be undertaken:

- (a) The bracing capacity of the wall linings be addressed to increase the seismic capacity to at least 67% NBS.
- (b) That the front canopy roof plane be braced or strengthened.
- (c) Intrusive investigations be undertaken to determine the capacity of the foundations.

10 Limitations

- (a) This report is based on an inspection of the structure with a focus on the damage sustained from the 22 February 2011 Canterbury Earthquake and aftershocks only.
- (b) Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at the time.
- (c) This report is prepared for the CCC to assist with assessing remedial works required for council structures and facilities. It is not intended for any other party or purpose.

11 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



Photo 1: Building frontage and side wall



Photo 2: Building frontage



Photo 3: Building side wall



Photo 4: Roof extension detail

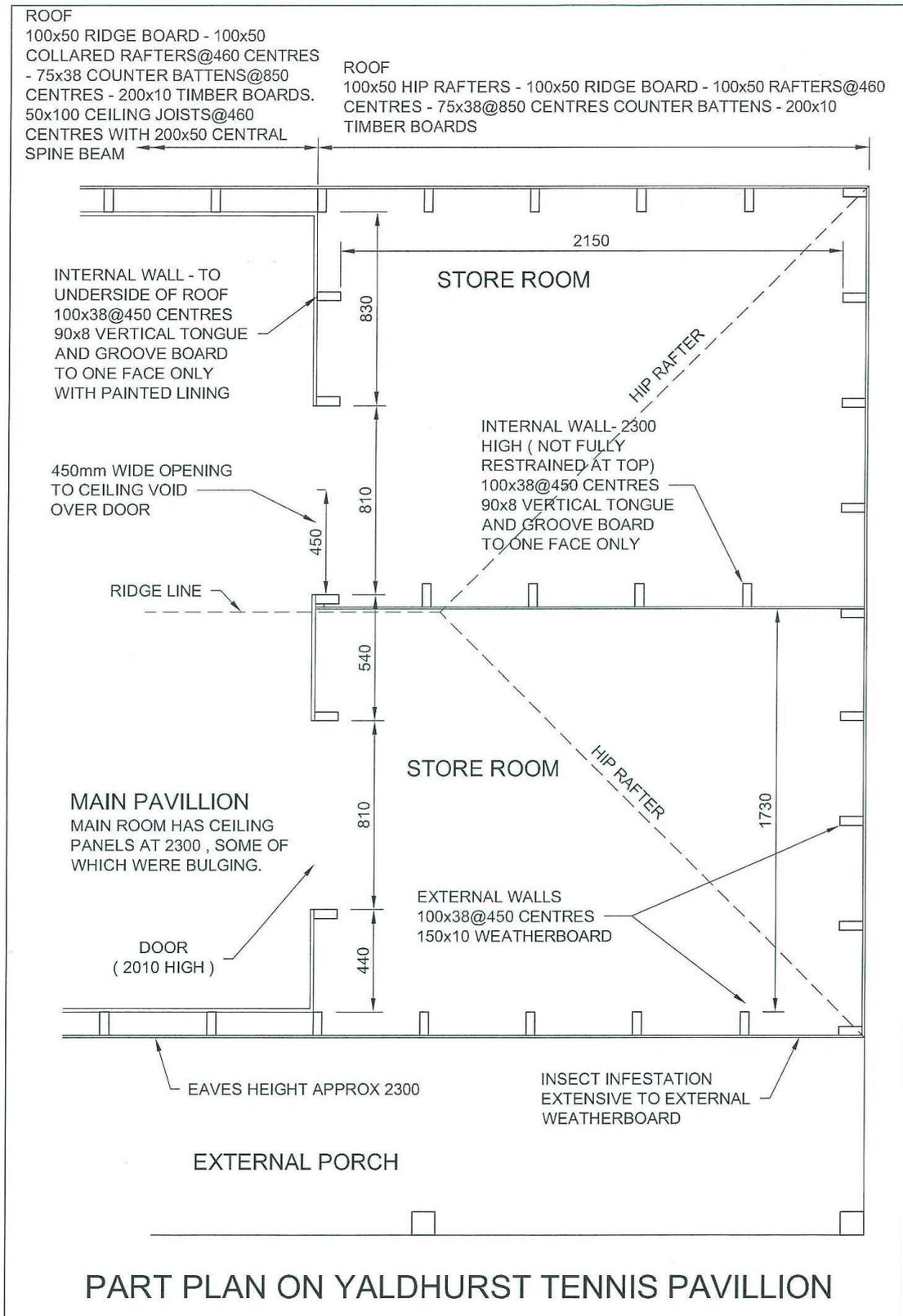


Photo 5: Typical social room vertical tongue and groove lining



Photo 6: Typical roof detail and wall junction

Appendix B – Part Building Plan



Appendix C – CERA DEEP Data Sheet

Location		Building Name: <input type="text" value="Yaldhurst Domain Tennis Pavilion"/>	Reviewer: <input type="text" value="Dave Dekker"/>
	Unit No: Street	CPEng No: <input type="text" value="1003026"/>	
Building Address: <input type="text" value="Yaldhurst Domain"/>		Company: <input type="text" value="Opus International Consultants"/>	
Legal Description: <input type="text"/>		Company project number: <input type="text" value="6-QUCCC.96"/>	
	Degrees Min Sec	Company phone number: <input type="text" value="03 3635400"/>	
GPS south: <input type="text"/>		Date of submission: <input type="text" value="16-Oct"/>	
GPS east: <input type="text"/>		Inspection Date: <input type="text" value="August & September 2012"/>	
Building Unique Identifier (CCC): <input type="text" value="PRK_1642_BLDG_002_EQ2"/>		Revision: <input type="text" value="Final"/>	
		Is there a full report with this summary? <input type="text" value="yes"/>	

Site	Site slope: <input type="text" value="flat"/>	Max retaining height (m): <input type="text"/>
	Soil type: <input type="text"/>	Soil Profile (if available): <input type="text"/>
	Site Class (to NZS1170.5): <input type="text" value="D"/>	
	Proximity to waterway (m, if <100m): <input type="text"/>	If Ground improvement on site, describe: <input type="text"/>
	Proximity to cliff top (m, if < 100m): <input type="text"/>	
	Proximity to cliff base (m,if <100m): <input type="text"/>	Approx site elevation (m): <input type="text"/>

Building	No. of storeys above ground: <input type="text" value="1"/>	single storey = 1	Ground floor elevation (Absolute) (m): <input type="text"/>
	Ground floor split? <input type="text"/>		Ground floor elevation above ground (m): <input type="text"/>
	Storeys below ground: <input type="text" value="0"/>		
	Foundation type: <input type="text" value="other (describe)"/>		if Foundation type is other, describe: <input type="text" value="concrete slab with perimeter footing"/>
	Building height (m): <input type="text" value="3.50"/>	height from ground to level of uppermost seismic mass (for IEP only) (m): <input type="text"/>	
	Floor footprint area (approx): <input type="text" value="36"/>		Date of design: <input type="text"/>
	Age of Building (years): <input type="text"/>		
	Strengthening present? <input type="text"/>		If so, when (year)? <input type="text"/>
	Use (ground floor): <input type="text"/>		And what load level (%g)? <input type="text"/>
	Use (upper floors): <input type="text"/>		Brief strengthening description: <input type="text"/>
	Use notes (if required): <input type="text"/>		
	Importance level (to NZS1170.5): <input type="text"/>		

Gravity Structure	Gravity System: <input type="text" value="frame system"/>	rafter type, purlin type and cladding
	Roof: <input type="text" value="timber framed"/>	slab thickness (mm)
	Floors: <input type="text" value="concrete flat slab"/>	<input type="text"/>
	Beams: <input type="text"/>	<input type="text"/>
	Columns: <input type="text"/>	<input type="text"/>
	Walls: <input type="text"/>	<input type="text"/>

Lateral load resisting structure	Lateral system along: <input type="text" value="other (note)"/>	Note: Define along and across in detailed report!	describe system <input type="text" value="T&G timber, weatherboard"/>
	Ductility assumed, μ: <input type="text" value="3.00"/>	0.00	estimate or calculation? <input type="text"/>
	Period along: <input type="text" value="0.30"/>		estimate or calculation? <input type="text"/>
	Total deflection (ULS) (mm): <input type="text"/>		estimate or calculation? <input type="text"/>
	maximum interstorey deflection (ULS) (mm): <input type="text"/>		
	Lateral system across: <input type="text" value="other (note)"/>		describe system <input type="text" value="T & G timber, weatherboard"/>
	Ductility assumed, μ: <input type="text" value="3.00"/>	0.00	estimate or calculation? <input type="text"/>
	Period across: <input type="text" value="0.30"/>		estimate or calculation? <input type="text"/>
	Total deflection (ULS) (mm): <input type="text"/>		estimate or calculation? <input type="text"/>
	maximum interstorey deflection (ULS) (mm): <input type="text"/>		estimate or calculation? <input type="text"/>

Separations:	north (mm): <input type="text"/>	leave blank if not relevant
	east (mm): <input type="text"/>	
	south (mm): <input type="text"/>	
	west (mm): <input type="text"/>	

Non-structural elements	Stairs: <input type="text"/>	<input type="text"/>
	Wall cladding: <input type="text"/>	<input type="text"/>
	Roof Cladding: <input type="text"/>	<input type="text"/>
	Glazing: <input type="text"/>	<input type="text"/>
	Ceilings: <input type="text"/>	<input type="text"/>
	Services(list): <input type="text"/>	<input type="text"/>

Available documentation	Architectural: <input type="text" value="none"/>	original designer name/date: <input type="text"/>
	Structural: <input type="text" value="none"/>	original designer name/date: <input type="text"/>
	Mechanical: <input type="text"/>	original designer name/date: <input type="text"/>
	Electrical: <input type="text"/>	original designer name/date: <input type="text"/>
	Geotech report: <input type="text"/>	original designer name/date: <input type="text"/>

Damage	Site performance: <input type="text" value="no damage identified"/>	Describe damage: <input type="text"/>
Site: (refer DEE Table 4-2)	Settlement: <input type="text"/>	notes (if applicable): <input type="text"/>
	Differential settlement: <input type="text"/>	notes (if applicable): <input type="text"/>
	Liquefaction: <input type="text"/>	notes (if applicable): <input type="text"/>
	Lateral Spread: <input type="text"/>	notes (if applicable): <input type="text"/>
	Differential lateral spread: <input type="text"/>	notes (if applicable): <input type="text"/>
	Ground cracks: <input type="text"/>	notes (if applicable): <input type="text"/>
	Damage to area: <input type="text"/>	notes (if applicable): <input type="text"/>

Building:	Current Placard Status: <input type="text"/>	
Along	Damage ratio: <input type="text" value="100%"/>	Describe how damage ratio arrived at: <input type="text"/>
	Describe (summary): <input type="text"/>	
Across	Damage ratio: <input type="text" value="100%"/>	$Damage_Ratio = \frac{(\%NBS\ (before) - \%NBS\ (after))}{\%NBS\ (before)}$
	Describe (summary): <input type="text"/>	
Diaphragms	Damage?: <input type="text"/>	Describe: <input type="text"/>
CSWs:	Damage?: <input type="text"/>	Describe: <input type="text"/>
Pounding:	Damage?: <input type="text"/>	Describe: <input type="text"/>
Non-structural:	Damage?: <input type="text"/>	Describe: <input type="text"/>

Recommendations	Level of repair/strengthening required: <input type="text" value="minor structural"/>	Describe: <input type="text" value="Upgrade wall bracing"/>
	Building Consent required: <input type="text"/>	Describe: <input type="text" value="Upgrade canopy roof plane bracing"/>
	Interim occupancy recommendations: <input type="text" value="full occupancy"/>	Describe: <input type="text"/>
Along	Assessed %NBS before: <input type="text" value="80%"/>	##### %NBS from IEP below
	Assessed %NBS after: <input type="text"/>	If IEP not used, please detail assessment methodology: <input type="text" value="DEE"/>
Across	Assessed %NBS before: <input type="text" value="58%"/>	##### %NBS from IEP below
	Assessed %NBS after: <input type="text"/>	

