New Zealand consulting engineers Limited

Seismic Assessment

of

Totara Lodge

for

Inverwell Industrial Investments Ltd

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Contents

1. Executive Summary

This report assesses the seismic capacity of Totara Lodge building using current design code. AS/NZS 1170.5:2004. This code is referred to as the "New Building Standard" (NBS).

The assessment is based on the assessment processes in the New Zealand Society for Earthquake Engineering (NZSEE) publication *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes*; this is the quasi-standard used for seismic assessment in New Zealand. It is colloquially known as the "Red Book".

This assessment concludes that the building structure has a New Building Standard value of 100%NBS in the lateral direction and 120%NBS in the longitudinal direction based on the lateral strength capacity of the building compared to the demand placed on it by a current code earthquake.

At 100 %NBS, the building has an "A Grade" rating according to NZSEE *Assessment and improvement of the Structural Performance of Buildings in Earthquakes*.

The methodology utilised in this report is different to other assessment, A first principles approach is taken.

The general approach to assess the seismic capacity of existing buildings is simple. This logic should be used to assess all older buildings. It has four distinct and initially unrelated steps:

- Understand the configuration of the building, its materials and construction details, and calculate its seismic mass. Understand its environs – step 1.
- Determine the lateral load **capacity** of the building – step 2.
- Determine the code seismic **demand** (lateral loads) on the building – step 3.
- Divide the lateral load **capacity** by the code seismic **demand** to obtain %NBS – step 4.

The detail and rigour in these four steps need to match the level of complexity of the building and its fabric together with any site specific issues.

2. Limitation

This report is not a condition report on the building. It is purely a Seismic Assessment. It does not cover any other building issues apart from *Structure – B2* in the Building Code.

3. Building description

Figure 3.1 Front elevation

The Totara Lodge is a multi-functional property. On site the functions are accommodation, restaurant, bar and hotel.

The original building was constructed in 1973 with a series of extensions and alterations taken place periodically in its life. The structure is timber frame in conjunction with a series of steel portal frames and timber lintel systems in the front section and under the upper storey apartment.

Recent timber frame housing has been developed to the rear of the site.

Location

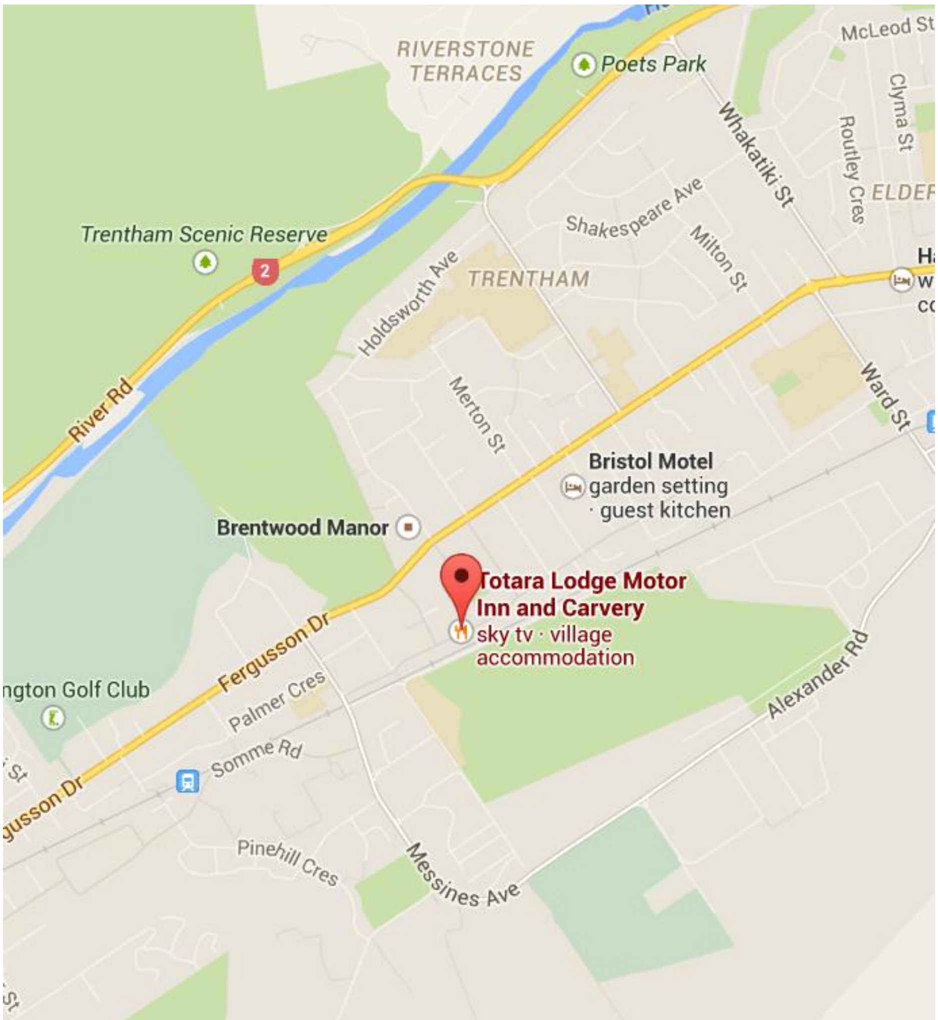

Figure 3.2 Location

Archives

Upper Hutt Council hold a wealth of information for this building in excess of 600 pages of various records including permits, drawings, calculations and alterations.

Access to this information is straightforward. The council have a computer at reception where one can access their records and pick out relevant documents. Printing costs here are miniscule. Digital copies can be more expensive, say $40.

Please refer to Appendix 3 for the select information we retrieved from archives.

Layout

The following diagram details the site layout identifying the additions over time.

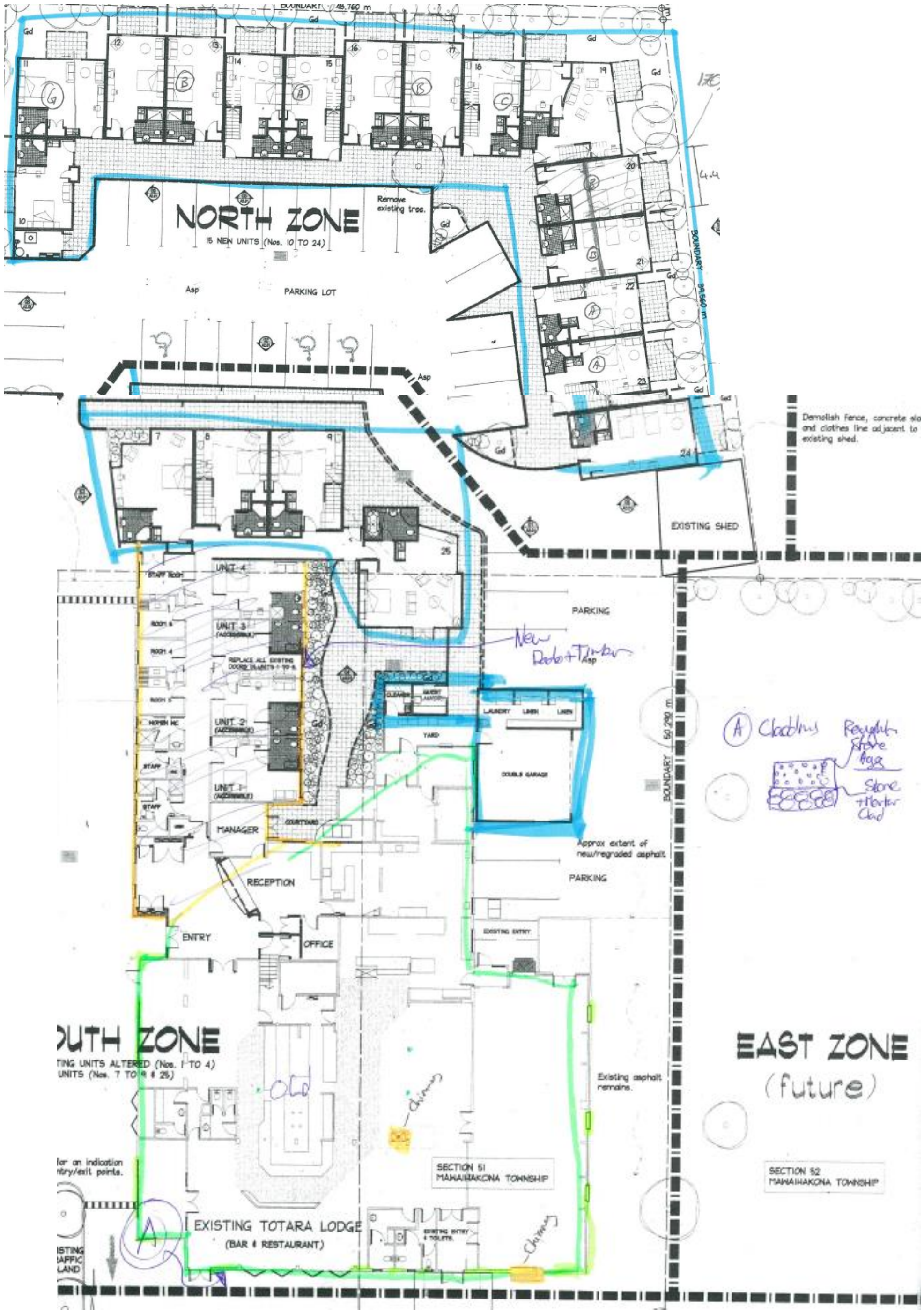

Figure 3.3 Layout

The original building constructed in the 1970s is highlighted in green. This area now functions as the restaurant and bar. Hotel accommodation added later is highlighted in orange and the newest construction to date is highlighted in blue.

4. Assessment methodology – general approach

The purpose of this section is an introduction as to how seismic assessments are undertaken. For a more detailed explanation, please refer to Appendix 2: Assessment Methodology.

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The detail and rigour in these four steps need to match the level of complexity of the building and its fabric together with any site specific issues.

4.1 Assessment methodology - Step 1 - Project data gathering

Collate and register all available documentation on the building regardless of the discipline. Include drawings, specifications, calculations and older photos.
Calculate the building elements' weights.

4.2 Assessment methodology - Step 2 - Determine the lateral capacity of the building

Assessing a building is completely different to designing a building. The key to assessing an existing building is to study it and understand how this particular building works. From this phenomena we can identify the building's strengths. The best method for achieving the buildings full potential is to study the fine detail of the building's construction from the ground up. This will give the building its optimum ability to achieve the true performance subject to seismic loading.

- Understand how the building works. Determine how the building will behave under seismic loading.
- Identify the elements of the building which will have the best effect at resisting seismic excitation.
- Calculate the maximum **capacity** of these components. Capacity refers to the ultimate state of stress achievable just before yield.
- Combine the relative **capacity** of these components to provide the strength of the building as a whole.
- The **capacity** of the building will be up against the **demand** placed on it due to a seismic load. These are completely independent calculations.

4.3 Assessment methodology - Step 3 - Determine the Code Design level demand

The **Demand** refers to the seismic force which a building may be subject to. The demand depends on a number of factors with varying degrees:

- Period
- Ductility
- Zone (the seismicity of the region within New Zealand)
- Subsoil Classification
- Importance level – Larger more “important” buildings are designed to resist higher load levels.
- Damping
- Soil structure interaction

The ductility, the period, the soil type and the damping all have a significant element of variability and judgement.
Generally, the seismic demand on a building can be reduced with greater engineering effort and understanding, which will benefit the resulting %NBS.

4.4 Assessment Methodology - Step 4 - Determine %NBS

The %NBS figure is simply the lateral load **capacity** of the building divided by the lateral load **demand** on the building.

The %NBS figure can fluctuate wildly if either the demand or the capacity (or both) are wrongly assessed.

The %NBS value can increase with increasing assessment effort to:

- Increase the CAPACITY
- Lower the DEMAND

5. Building Capacity

5.1 Introduction

Assessment methodology utilised involved determining the **capacity** of the structure and comparing that to the **demand** placed on the structure in accordance to the code. The %NBS has been calculated by dividing the capacity by the demand.

5.2 Capacity

The capacity of the original building has been calculated utilising the timber frame walls and the portal frames. The building is analysed in two directions. The lateral (east - west) and longitudinal (north – south). The direction which attains the lower value is taken as the building's performance as a whole for the %NBS rating.

The following drawing displays the 1970s structure.

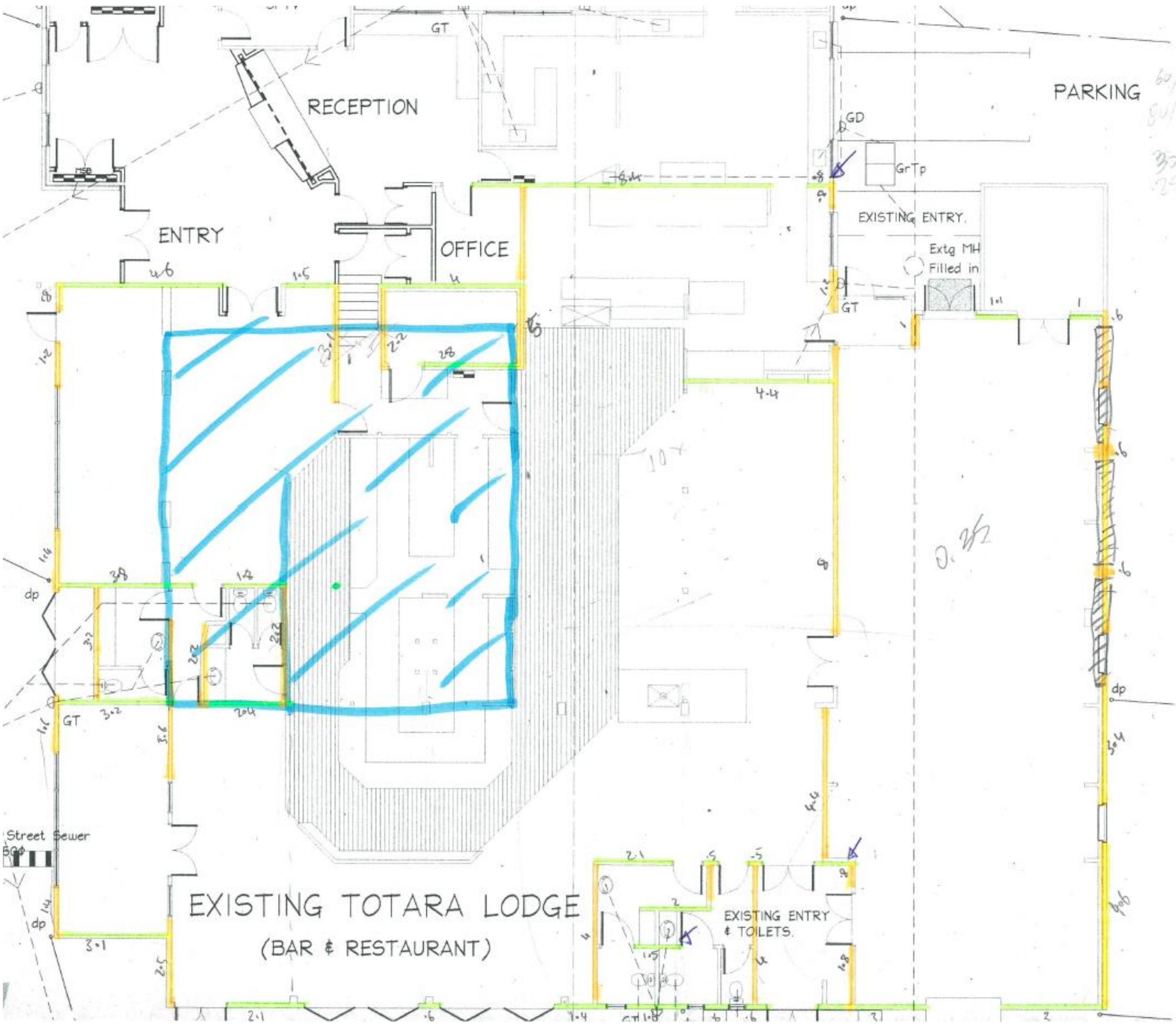

Figure 5.1 Totara lodge 1970s structure

The portal frames add a great amount of capacity to the building. The following drawing displays the portal frame to the underside of the second storey apartment.

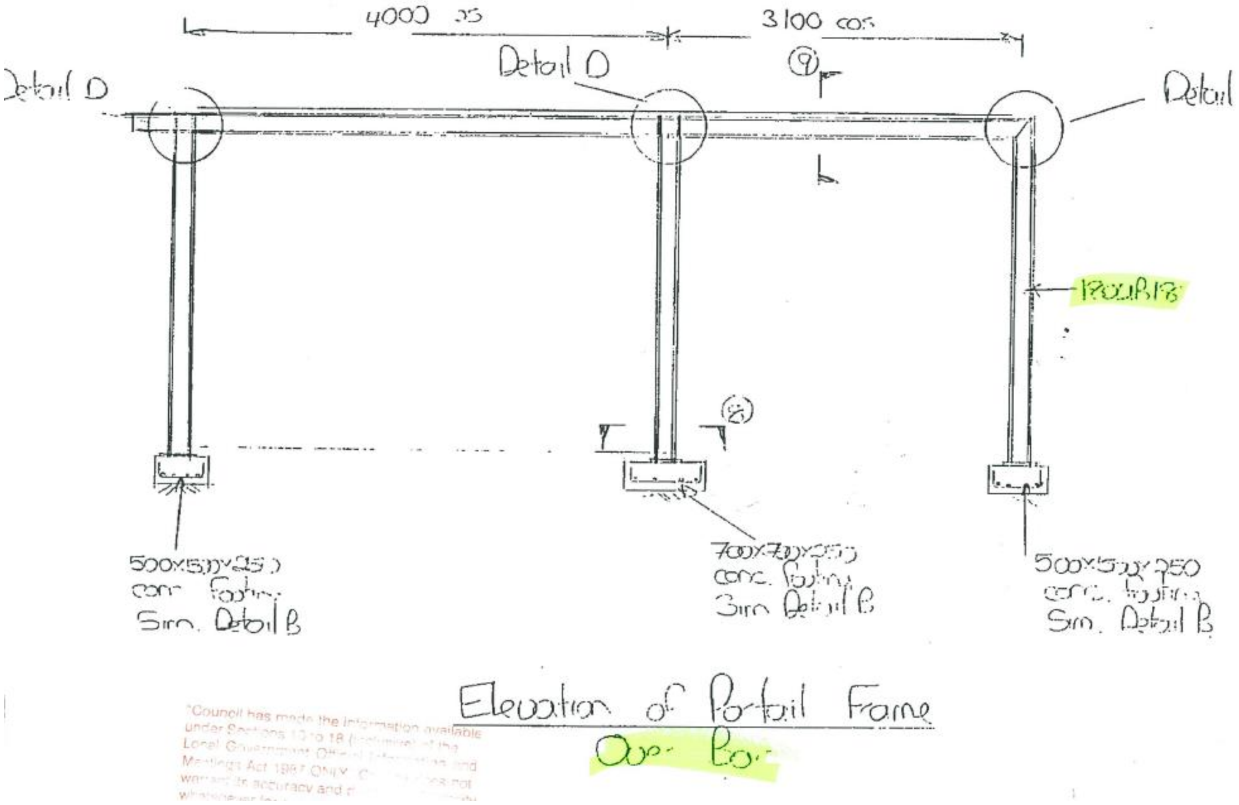

Figure 5.2 Portal frame

The following results refer to a measure of force known as “bracing units”, *BU*. Twenty bracing units is equivalent to one kilo newton, *kN.* 1*kN* = 20*BU*

Lateral direction

Capacity in the lateral direction is *2,292 BU.* The walls contribute *1,452 BU* and the portal frame contributes *840 BU.*

Longitudinal direction

Capacity in the longitudinal direction is *2,775 BU.* The walls contribute *1,775 BU* and the portal frames contributes *1,000 BU.*

Please refer to Appendix 1 for calculations.

6. Demand

Seismic **demand** calculation is completely separate to calculating the **capacity** of the building.

Seismic demand varies in different areas across New Zealand due to seismic history and proximity to fault lines. Also considered in seismic demand is the building usage, the soil it bears upon and the building's construction.

Please see the following table for the demand calculated is *2,276 BU.*

7. Determine %NBS, New Building Standard

7.1 General

The %NBS is the building's **capacity** to resist seismic forces, divided by the seismic **demand** calculated for the building. The lesser of the performance in the two directions is taken as the result for the building.

7.2 Calculation

Longitudinal Direction		
Consideration	Value *BU*	Percent NBS *%NBS*
Seismic Weight kN	430	
Seismic Demand BU	2276	
Capacity BU - Wall	1775	78%
Capacity BU - Portal frame	1000	44%
Capacity BU	2775	**122%**

Lateral Direction		
Consideration	Value *BU*	Percent NBS *%NBS*
Seismic Weight kN	430	
Seismic Demand BU	2276	
Capacity BU - Wall	1452	64%
Capacity BU - Portal frame	840	37%
Capacity BU	2292	**101%**

Figure 7.1 Calculation of %NBS

Laterally, **the building performs to 100%NBS**, considering the structure to be "ductile" with a ductility factor of 2.5 applied.

Longitudinally, **the building performs to 120%NBS**, considering the structure to be "ductile" with a ductility factor of 2.5 applied.

The building rating is taken as the lowest of the two and is therefore rated at **100%NBS**

According to "*NZSEE Assessment and improvement of the Structural Performance of Buildings in Earthquakes"*, The Banks Apartments property achieves a Grade A+.

8. The New Zealand Society for Earthquake Engineering Grading Scheme

8.1 Extract from NZSEE outlining the scheme

In addition to the legislative requirements, the NZSEE is keen to introduce into the property market a system for grading buildings according to their assessed structural performance. The aim is to raise awareness in the industry and allow market forces to work in reducing earthquake risk. In time, owners of lowest grades of buildings would find themselves under pressure to improve them or face loss of revenue.

Table 2.1 indicates the grading scheme proposed. This is linked to the %NBS value. Determining the earthquake risk grade of a building would be a simple matter of determining into which grade band the calculated %NBS of the building falls.

Note that the grade is not required by the Act, but is seen by NZSEE as a highly desirable mechanism to bring about improvement of structural performance.

Table 2.1 includes an indication of the relative risk for buildings designed at different times. The relative risk represented by the progressively decreasing %NBS shows the importance of dealing with those buildings with less than or equal to 33%NBS – they have 20 or more times the risk of their strength being exceeded due to earthquake actions.

Table 2.1: Grading system for earthquake risk

Percentage of New Building Standard (%NBS)	Letter grade	Relative risk (approx)	NZS 4203: 1976 or better	1965–76 No CSWs	1935–65 No CSWs	2/3 Chapter 8	Buildings with CSWs
>100	A+	< 1 time					
80–100	A	1–2 times					
67–80	B	2–5 times					
33–67	C	5–10 times					
20–33	D	10–25 times					
<20	E	> 25 times					

Note changes to the relative risk values have been made to line up with the values in Table C4.4.

Notes:

1) *%NBS* is the percentage new building standard score for a particular building
2) Values shown for *%NBS* for building groups are indicative only and will vary with location, assessed ductility, features. Many buildings may have been designed for more than the minimum requriements of the Standards of the day.
3) Letter grade is an indicator of likely performance in earthquake.
4) Relative risk (RR) is the ratio of probabilities that the ultimate strength will be exceeded in any given period of time, i.e. RR = (probability for existing building with *%NBS* value shown) ÷ (probability for building with 100*%NBS*).
5) CSW stands for critical structural weaknesses.

The NZSEE Study Group sought to summarise its views on how buildings of various risk levels should be regarded. The result is shown in Table 2.2. Buildings that do not comply with the minimum requirements of the proposed changes to the Act (i.e. ≤33*%NBS*) are regarded as High Risk Buildings. Those with > 67*%NBS* are regarded as being Low Risk. This leaves a group in between that meet the requirements of the Act but cannot be regarded as Low Risk. These have been termed Moderate Risk.

These definitions differ from the requirements of the Act. The Act requires that buildings be improved to at least 34*%NBS*. Table 2.2 indicates the difference.

Table 2.2 NZSEE Risk Classifications and Improvement Recommendations

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)	Unacceptable	Unacceptable

8.2 Resulting building Seismic Assessment

The building is assessed at 100

%NBS. Thus the building has a “A Grade” rating from NZSEE table 2.1 and is Moderate Risk in terms of table 2.2. The performance of the building is acceptable.

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Appendix 1: Calculations

Appendix 2: Assessment Methodology

Appendix 3: Drawings and Calculations from Upper Hutt Archives