GWRL Bridge and Subway Initial Seismic Assessment - Waterloo Subway BR17A NIMT Report

Prepared by Calibre Consulting
Prepared for Greater Wellington Rail Limited
17 September 2015
Original
Buildings & Structures

COMMERCIAL IN CONFIDENCE

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708533 A1P GWRL WATERLOO SUBWAY ISA REPORT 2015 0917

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EXECUTIVE SUMMARY

BACKGROUND

This is a summary of the Initial Seismic Assessment (ISA) report for the Waterloo Subway based on the New Zealand Society for Earthquake Engineering (NZSEE) Initial Evaluation Procedure (IEP) and visual inspections undertaken on 18 August 2015. We also carried out simple structural calculations for Initial Seismic Assessment.

As-Built Drawings of the Waterloo subway could not be located. In the absence of As-Built Drawings, we have assumed that the date of construction is circa 1950 consistent with construction of the subways in the vicinity of Waterloo.

CRITICAL STRUCTURAL WEAKNESSES

We have not identified any critical structural weakness.

SEISMIC BUILDING CAPACITY (%NBS)

Based on the information available, the NZSEE Initial Evaluation Procedure assessed the seismic capacity of the Waterloo Subway to be in the order of 45% new building standard (NBS). The subway is, therefore, regarded as being Moderate Risk but not likely to be earthquake prone. Calculations on the strength of subways at Epuni, Naenae and Taita indicate the seismic capacities of the tunnels and ramp walls to be 100%NBS and 50% to 100%NBS, respectively. We would expect similar results for Waterloo.

RECOMMENDATIONS

There is no legal requirement for any further action as the seismic rating of the subway is greater than 34%.

1 INTRODUCTION

Calibre Consulting Ltd has been engaged by Greater Wellington Rail Limited (GWRL) to carry out an Initial Seismic Assessment (ISA) of the Waterloo Subway at Waterloo Railway Station, Hutt Valley.

s7(2)(a) [redacted] of Calibre Consulting carried out a visual inspection of the subway and ramps on 18 August 2015. Photographs that were taken are included in Appendix A. The inspection was limited to those elements that were readily observable. The subway walls and retaining walls are covered with ceramic tiles and it was not possible to be inspected where they were covered. Construction drawings were made available and these have been considered in our evaluation of the structure. The structure description in this report is based on review of the drawings and our visual inspections.

Calibre Consulting has carried out the Initial Evaluation Procedure (IEP), in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) recommendations on Assessment and Improvement of the Structural Performance of Buildings in Earthquakes [Ref 1]. At this stage, we have not carried out any geotechnical investigations and our inspection was a non-intrusive one.

2 BUILDING ACT AND HUTT CITY COUNCIL REQUIREMENTS

2.1 BUILDING ACT 2004

Several sections of the Building Act are relevant when considering the earthquake-prone status of a building.

Section 122: Meaning of earthquake-prone building.

This section defines a building as earthquake-prone if the building will have its ultimate capacity exceeded in a moderate earthquake; and would be likely to collapse causing injury or death to persons in the building or to persons or any other property; or damage any other property.

The Building Regulations 2005 defines a moderate earthquake as an earthquake that would generate shaking at the site of the building that is of the same duration as, but that is one-third as strong as, the earthquake shaking that would be used to design a new building at the site.

Section 124: Dangerous, affected, earthquake-prone or insanitary buildings: powers of territorial authority.

This section gives powers to the territorial authority to issue a notice requiring work to be carried out to reduce or remove the danger within a specified timeframe, to put up a hoarding or fence to prevent people from approaching the building or to attach a notice to the building that warns people not to approach the building if the territorial authority is satisfied that a building is earthquake prone.

Section 131: Policy on dangerous, earthquake-prone, and insanitary buildings.

This section requires the territorial authority to adopt a policy on dangerous, earthquake-prone, and insanitary buildings within its district.

The territorial authority in this case is the Hutt City Council.

2.2 HUTT CITY COUNCIL EARTHQUAKE – PRONE BUILDING POLICY

Hutt City Council adopted their Earthquake - Prone Building Policy in November 2011 and a subsequent amendment was approved by Council in September 2013. This policy includes the following:

Council strongly recommends that all buildings be strengthened to a minimum of 67% New Building Standard (NBS). Council will require all buildings to be strengthened to 34% of NBS by 2018, with the exception of:

a) A building that has been strengthened under policy set by Council in 2006 that allows heritage and historic buildings to be strengthened to a level just above 33%NBS and all other earthquake-prone buildings required to restrengthen to 50%NBS; or
b) Where a building consent has been issued and strengthening work has commenced.

3 BACKGROUND TO THE IEP

The IEP procedure, developed by the New Zealand Society for Earthquake Engineering (NZSEE), is a tool to assign a percentage of New Building Standard (*%NBS*) score and associated grade to a building as part of an initial seismic assessment of existing buildings.

The IEP enables territorial authorities, building owners and managers to review their building stock as part of an overall risk management process.

Characteristics and limitations of the IEP include:

- The IEP assessment tends to be conservative, identifying some buildings as earthquake prone, or having a lower *%NBS* score, which subsequent detailed investigation may indicate is less than actual performance. However, there will be exceptions, particularly when critical structural weaknesses (CSWs) are present that have not been recognised from the level of investigation employed.
- It can be undertaken with variable levels of available information, exterior only inspection, structural drawings, interior inspection, etc. The more information available the more accurate the IEP result is likely to be. The IEP records the information that has formed the basis of the assessment and consideration of this is important when determining the likely reliability of the result.
- It is an initial, first-stage review. Buildings or specific issues which the IEP process flags as being problematic or as having potential critical structural weaknesses, need further detailed investigation and evaluation. A Detailed Seismic Assessment is recommended if the seismic status of a building is critical to any decision making.
- The IEP assumes that the buildings have been designed and built in accordance with the building standard and good practice current at the time. In some instances, a building may include design features ahead of its time - leading to better than predicted performance. Conversely, some unidentified design or construction issues not picked up by the IEP process may result in the building performing not as well as predicted.
- The IEP is a largely qualitative process, and should be undertaken or overseen by an experienced and chartered professional engineer. It requires considerable knowledge of the earthquake behaviour of buildings, and judgement as to key attributes and their effect on building performance. Consequently, it is possible that the *%NBS* derived for a building by independent experienced engineers may differ.
- An IEP may over-penalise some apparently critical features which could have been satisfactorily taken into account in the design.
- An IEP does not take into account the seismic performance of non-structural items.

Experience to date is that the IEP is a useful tool to identify potential issues and the expected overall performance of a building in an earthquake. However, the process and the associated %NBS and grade should be considered as only indicative of the building compliance with current code requirements. A detailed investigation and analysis of the building will typically be required to provide a definitive assessment.

An IEP score above 34*%NBS* should be considered sufficient to classify the building as not earthquake prone. However, if further information becomes available, reassessment may be required.

4 EARTHQUAKE RESISTANCE STANDARDS

For this assessment, the subway'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 new building standard load requirements have been determined in accordance with the current earthquake loading standard (NZS 1170.5:2004 Structural design actions - Earthquake actions - New Zealand).

The likely capacity of this subway has been derived in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) guidelines 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes' (AISPBE), June 2006 (as amended on 12 Sept 2014).

The New Zealand Society for Earthquake Engineering has proposed a way for classifying earthquake risk for existing buildings in terms of %NBS and this is shown in Figure 4.1 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	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	Unacceptable	Unacceptable

Figure 4-1: NZSEE Risk Classifications Extracted from Table 2.2 of the NZSEE 2006 AISPBE Guidelines

Table 4.1 below compares the percentage NBS to the relative risk of a building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year).

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

Table 4-1: %NBS compared to relative risk of failure

5 STRUCTURE DESCRIPTION

Since the As-Built Drawings of the Subway at Waterloo Interchange (Hutt Central) Railway Station are not available, the As-Built Drawings of the other railway subways in the region which were built in the same period were the basis for this assessment.

The drawings for the other railway subways were dated 1959 and the Waterloo subway is assumed to have been constructed around that time. The subway has been refurbished but we have been unable to find details of any changes.

The subway is a reinforced concrete box section and the ramps and steps leading to the subway have cantilevered reinforced concrete retaining walls.

Refer to the attached drawings (Appendix C) and photos (Appendix B) for further details of construction of the subway.

Figure 5-1: Waterloo Station

6 STRUCTURAL SYSTEMS

Gravity loads and live loads on the subway are supported by the reinforced concrete roof slab and transferred to reinforced concrete walls. The walls transfer the loads to the base slab and to the ground.

Seismic loads in the longitudinal (along the subway) are resisted by the reinforced concrete subway wall acting as a shear wall. Seismic loads in the transverse direction are resisted by bending strength in the wall spanning between base slab and roof slab.

Seismic loads on ramp walls in the transverse direction as resisted by the wall acting as a cantilever and transferred to the base slab.

7 CURRENT CONDITION OF THE STRUCTURE

The subway structure is in a good condition.

Some hair-line cracks can be observed in the tile cover on the wall an observed but it is not conclusive if the cracks are due to structural damage. (Appendix B Photos 4 & 5).

Earthquake damage on any part of the subway were not observed.

8 STRUCTURE ASSESSMENT

A detailed seismic assessment (DSA) of this subway has not been undertaken. However we have assessed the capacity of the key structural elements of the subway.

Our assessment is based on the Initial Evaluation Procedure (IEP) as set out in the New Zealand Society for Earthquake Engineering (NZSEE) document "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes". The purpose of the IEP is "to identify, with a reasonable confidence level, all those buildings that will be potentially earthquake prone" i.e. those buildings whose capacity is assessed at less than 34% of New Building Standard (NBS). The process compares the performance of existing structures against the standards required for a new structure. The output is expressed as a percentage of New Building Standard (%NBS).

We have used the following parameters for the IEP and the calculations of the seismic capacity of the key members.

<u>Seismic Parameters</u>

- The seismic design parameters used are based on current design requirements from NZS1170:2002, and for this structure are as follows:
- Year of Design – 1935-1965 – In the same period as the other railway subways in the region. Due to no available As-Built Drawing for the Waterloo Subway, the date was based on the As-Built drawings for other railway subways in the Wellington Region).
- Building Type – Public Building.
- Site soil class: C – NZS 1170.5:2004, Clause 3.1.3, Shallow Soil Sites.
- Estimate Period: T=0.40 sec as 'user defined (all other options are for building type)
- Near Fault Factor: N(T,D) = 1 for both Longitudinal and Transverse (for Wellington Region)
- Hazard Scaling factor, Z = 0.4 for Hutt Valley – South of Taita Gorge, NZS 1170.5:2004, Table 3.3
- Ductility Scaling Factor, Available Displacement Ductility Within Existing Structure, μ = 1.50 for Masonry-Long Wall
- Return period factor R_u = 1 – NZS 1170.5:2004, Table 3.5, Importance level 2 structure with a 50 year design life, (not a principal railway station with a capacity > 250)

We assess the Waterloo Substation to have a current seismic capacity of 45% NBS as per the attachment in Appendix B. This assessment has been made on the assumption that the ductility scaling factor for the subway is μ=1.5, relating to the reinforced concrete walls resisting lateral loads in both the longitudinal and transverse directions. We have assumed no significant plan irregularity. The walls are reasonably symmetrically arranged.

This assessment indicates that the subway is not likely to be earthquake prone. The IEP process of assessment is an approximate one. A detailed seismic assessment, including more detailed calculations, is a more accurate method and may result in a better rating for this structure.

9 CONCLUSION & RECOMMENDATIONS

The IEP value for Porirua Subway is assessed at 45%NBS in terms of the New Zealand Society for Earthquake Engineering (NZSEE) document “Assessment and Improvement of the Structural Performance of Buildings in Earthquakes and accordingly this means that the structure is categorised as Moderate Risk, but not Earthquake Prone.

There is no legal requirement for any further action as the seismic rating of the subway is greater than 34%.

IMPORTANT DISCLAIMER

This report has been prepared by Calibre Consulting Ltd for Greater Wellington Rail Limited. No liability is accepted by Calibre Consulting Ltd or any employee or sub-consultant of Calibre Consulting Ltd with respect to its use by any other parties. This disclaimer shall apply notwithstanding that the report may be made available to other persons for an application for permission or approval to fulfil a legal requirement.

Unless stated otherwise, this report and assessment herein are based on a visual and non-intrusive walk-around inspection of the subway and subway drawings.

Calibre Consulting has not carried out a detailed seismic assessment, and we have not commented on the subway's degree of compliance with the New Zealand Building Act or any other relevant codes or standards other than the structural aspects.

In accepting delivery and/or use of this report, the recipient agrees that they accept the report on the basis set out herein.

APPENDICES

APPENDIX A WATERLOO SUBWAY PHOTOS

Photo 1 - Tunnel

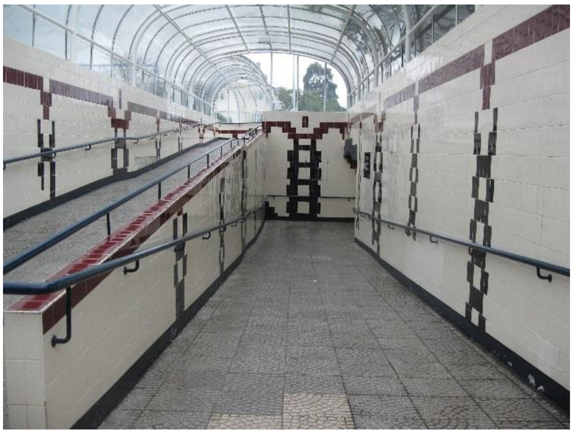

Photo 2 – Ramp Showing Cantilever Wall

Photo 3 - Ramp

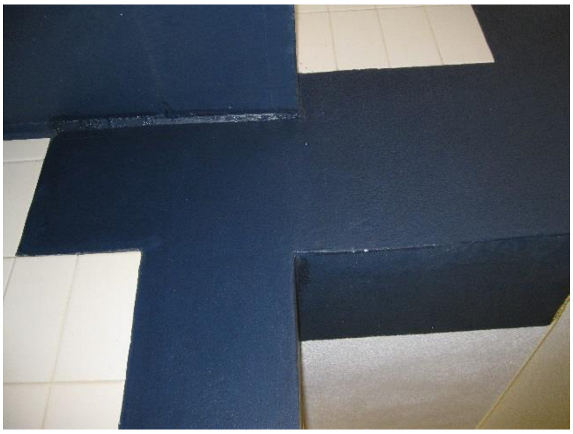

Photo 4 –Hair Line Cracks at the End of Tunnel

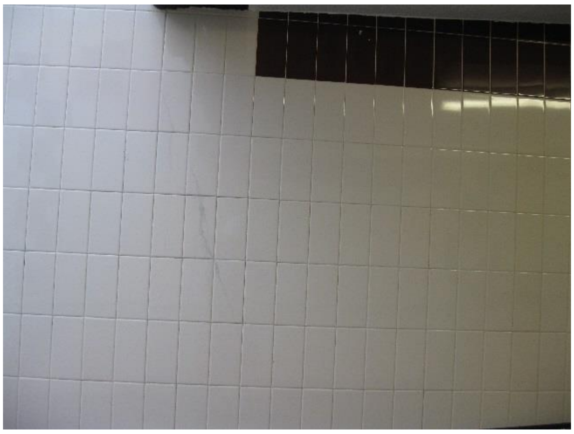

Photo 5 – Hair Line Cracks in the Wall Tiles

Photo 6 – Sediments at the Floor at the End of Tunnel due to Leaks

APPENDIX B WATERLOO SUBWAY IEP SUMMARY AND CAPACITY CALCULATIONS OF CRITICAL STRUCTURAL MEMBERS

Initial Evaluation Procedure (IEP) Assessment - Completed for GWRL

Street Number & Name:	**Waterloo Interchange (Hutt Central) Railway Station**	**Job No.:**	708533
AKA:	**Walterloo Station**	**By:**	s7(2)(a) [redacted]
Name of building:	**Waterloo Station Subway**	**Date:**	1/09/2015
City:	**Hutt Valley**	**Revision No.:**	**A**

Table IEP-1 Initial Evaluation Procedure Step 1

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)

1.2 Sketches (plans etc, show items of interest)

No Drawing Is Available.

NOTE: THERE ARE MORE SKETCHES ON PAGE 1a ATTACHED

1.3 List relevant features (Note: only 10 lines of text will print in this box. If further text required use Page 1a)

1.4 Note information sources Tick as appropriate

Visual Inspection of Exterior	☐	Specifications	☐
Visual Inspection of Interior	☑	Geotechnical Reports	☐
Drawings (note type)	☐	Other (list)	☐

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City:	Hutt Valley	**Revision No.:**	A

Table IEP-2 Initial Evaluation Procedure Step 2

Step 2 - Determination of *(%NBS)*$_b$

(Baseline *(%NBS)* for particular building - refer Section B5)

2.1 Determine nominal *(%NBS)* = *(%NBS)*$_{nom}$

	Longitudinal	Transverse
a) Building Strengthening Data		
Tick if building is known to have been strengthened in this direction	☐	☐
If strengthened, enter percentage of code the building has been strengthened to	N/A	N/A
b) Year of Design/Strengthening, Building Type and Seismic Zone		
Pre 1935	○	○
1935-1965	◉	◉
1965-1976	○	○
1976-1984	○	○
1984-1992	○	○
1992-2004	○	○
2004-2011	○	○
Post Aug 2011	○	○
Building Type:	Public Buildings	Public Buildings
Seismic Zone:		
c) Soil Type		
From NZS1170.5:2004, Cl 3.1.3 :	C Shallow Soil	C Shallow Soil
From NZS4203:1992, Cl 4.6.2.2 : (for 1992 to 2004 and only if known)	Flexible	Flexible

d) Estimate Period, *T*

Comment:

RC Frame for Tunnel

		Longitudinal	Transverse
h_n =		4.4	4.4 m
A_c =		3.23	1.00 m^2
Moment Resisting Concrete Frames:	$T = \max\{0.09h_n^{0.75}, 0.4\}$	○	◉
Moment Resisting Steel Frames:	$T = \max\{0.14h_n^{0.75}, 0.4\}$	○	○
Eccentrically Braced Steel Frames:	$T = \max\{0.08h_n^{0.75}, 0.4\}$	○	○
All Other Frame Structures:	$T = \max\{0.06h_n^{0.75}, 0.4\}$	○	○
Concrete Shear Walls	$T = \max\{0.09h_n^{0.75}/A_c^{0.5}, 0.4\}$	◉	○
Masonry Shear Walls:	$T \leq 0.4\text{sec}$	○	○
User Defined (input Period):		○	○
T:		0.40	0.40

Where h_n = height in metres from the base of the structure to the uppermost seismic weight or mass.

			Longitudinal	Transverse
e) Factor A:	Strengthening factor determined using result from (a) above (set to 1.0 if not strengthened)	Factor A:	1.00	1.00
f) Factor B:	Determined from NZSEE Guidelines Figure 3A.1 using results (a) to (e) above	Factor B:	0.04	0.04
g) Factor C:	For reinforced concrete buildings designed between 1976-84 Factor C = 1.2, otherwise take as 1.0.	Factor C:	1.00	1.00
h) Factor D:	For buildings designed prior to 1935 Factor D = 0.8 except for Wellington where Factor D may be taken as 1, otherwise take as 1.0.	Factor D:	1.00	1.00
***(%NBS)*$_{nom}$ = AxBxCxD**		*(%NBS)*$_{nom}$	4%	4%

WARNING!! *This initial evaluation has been carried out solely as an initial seismic assessment of the building following the procedureset out in the New Zealand Society for Earthquake Engineering document "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes, June 2006". This spreadsheet must be read in conjunction with the limitations set out in the accompanying report, and should not be relied on by any party for any other purpose. Detailed ins pections and engineering calculations, or engineering judgements based on them, have not been undertaken, and these may lead to a different result or seismic grade.*

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Table IEP-2 Initial Evaluation Procedure Step 2 continued

2.2 Near Fault Scaling Factor, Factor E

If $T \leq 1.5$sec, Factor E = 1

			Longitudinal	Transverse
a) Near Fault Factor, *N(T,D)* (from NZS1170.5:2004, Cl 3.1.6)		N(T,D):	1	1
b) Factor E	= 1/N(T,D)	Factor E:	1.00	1.00

2.3 Hazard Scaling Factor, Factor F

a) Hazard Factor, *Z*, for site

Location: Hutt Valley-south of Taita Gc — Refer right for user-defined locations

Z = 0.4 (from NZS1170.5:2004, Table 3.3)

Z_{1992} = 1.2 (NZS4203:1992 Zone Factor from accompanying Figure 3.5(b))

Z_{2004} = 0.4 (from NZS1170.5:2004, Table 3.3)

b) Factor F

For pre 1992 = $1/Z$

For 1992-2011 = Z_{1992}/Z

For post 2011 = Z_{2004}/Z

	Longitudinal	Transverse
Factor F:	2.50	2.50

2.4 Return Period Scaling Factor, Factor G

a) Design Importance Level, I

(Set to 1 if not known. For buildings designed prior to 1965 and known to be designed as a public building set to 1.25. For buildings designed 1965-1976 and known to be designed as a public building set to 1.33 for Zone A or 1.2 for Zone B. For 1976-1984 set I value.)

b) Design Risk Factor, R_o

(set to 1.0 if other than 1976-2004, or not known)

c) Return Period Factor, R

(from NZS1170.0:2004 Building Importance Level)

Choose Importance Level ○1 ◉2 ○3 ○4 (Longitudinal); ○1 ◉2 ○3 ○4 (Transverse)

d) Factor G = IR_o/R

	Longitudinal	Transverse
I =	1.25	1.25
R_o =	1	1
R =	1.0	1.0
Factor G:	1.25	1.25

2.5 Ductility Scaling Factor, Factor H

a) Available Displacement Ductility Within Existing Structure

Comment:
Masonry-Long Wall

μ = 1.50 (Longitudinal); 1.50 (Transverse)

b) Factor H

		Longitudinal k_μ	Transverse k_μ
For pre 1976 (maximum of 2)	=	1.29	1.29
For 1976 onwards	=	1	1
Factor H:		1.29	1.29

(where $k\mu$ is NZS1170.5:2004 Inelastic Spectrum Scaling Factor, from accompanying Table 3.3)

2.6 Structural Performance Scaling Factor, Factor I

a) Structural Performance Factor, S_p

(from accompanying Figure 3.4)

Tick if light timber-framed construction in this direction ☐ ☐

	Longitudinal	Transverse
S_p =	0.85	0.85

b) Structural Performance Scaling Factor = $1/S_p$

	Longitudinal	Transverse
Factor I:	1.18	1.18

Note Factor B values for 1992 to 2004 have been multiplied by 0.67 to account for Sp in this period

2.7 Baseline *%NBS* for Building, $(\%NBS)_b$

(equals $(\%NBS)_{nom}$ x E x F x G x H x I)

Longitudinal	Transverse
17%	17%

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Initial Evaluation Procedure (IEP) Assessment - Completed for GWRL **Page 4**

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Table IEP-3 Initial Evaluation Procedure Step 3

Step 3 - Assessment of Performance Achievement Ratio (PAR)

(Refer Appendix B - Section B3.2)

a) Longitudinal Direction

potential CSWs — **Effect on Structural Performance** (Choose a value - Do not interpolate) — **Factors**

3.1 Plan Irregularity

Effect on Structural Performance ○ *Severe* ○ *Significant* ⊙ *Insignificant* **Factor A** 1.0

Comment

3.2 Vertical Irregularity

Effect on Structural Performance ○ *Severe* ○ *Significant* ⊙ *Insignificant* **Factor B** 1.0

Comment

3.3 Short Columns

Effect on Structural Performance ○ *Severe* ○ *Significant* ⊙ *Insignificant* **Factor C** 1.0

Comment

3.4 Pounding Potential

(Estimate D1 and D2 and set D = the lower of the two, or 1.0 if no potential for pounding, or consequences are considered to be minimal)

a) Factor D1: - Pounding Effect

Note:
Values given assume the building has a frame structure. For stiff buildings (eg shear walls), the effect of pounding may be reduced by taking the coefficient to the right of the value applicable to frame buildings.

Factor D1 For Longitudinal Direction: 1.0

Table for Selection of Factor D1	Severe	Significant	Insignificant
Separation	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Alignment of Floors within 20% of Storey Height	○ 1	○ 1	⊙ 1
Alignment of Floors not within 20% of Storey Height	○ 0.4	○ 0.7	○ 0.8

Comment

b) Factor D2: - Height Difference Effect

Factor D2 For Longitudinal Direction: 1.0

Table for Selection of Factor D2	Severe	Significant	Insignificant
	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Height Difference > 4 Storeys	○ 0.4	○ 0.7	○ 1
Height Difference 2 to 4 Storeys	○ 0.7	○ 0.9	○ 1
Height Difference < 2 Storeys	○ 1	○ 1	⊙ 1

Comment

Factor D 1.0

3.5 Site Characteristics - *Stability, landslide threat, liquefaction etc as it affects the structural performance from a life-safety perspective*

Effect on Structural Performance ○ *Severe* ○ *Significant* ⊙ *Insignificant* **Factor E** 1.0

Comment

3.6 Other Factors - *for allowance of all other relevant characterstics of the building*

For ≤ 3 storeys - Maximum value 2.5
otherwise - Maximum value 1.5.
No minimum.

Factor F 2.5

Record rationale for choice of Factor F:

Seismic capacity calculation of the key elements of the structure indicated a capacity greater than 34%NBS

3.7 Performance Achievement Ratio (PAR)
(equals **A x B x C x D x E x F**)

PAR
Longitudinal 2.50

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Table IEP-3 Initial Evaluation Procedure Step 3

Step 3 - Assessment of Performance Achievement Ratio (PAR)

(Refer Appendix B - Section B3.2)

b) Transverse Direction

Factors

potential CSWs

Effect on Structural Performance
(Choose a value - Do not interpolate)

3.1 Plan Irregularity

Effect on Structural Performance ( ) *Severe* ( ) *Significant* (•) *Insignificant* **Factor A** 1.0

Comment

3.2 Vertical Irregularity

Effect on Structural Performance ( ) *Severe* ( ) *Significant* (•) *Insignificant* **Factor B** 1.0

Comment

3.3 Short Columns

Effect on Structural Performance ( ) *Severe* ( ) *Significant* (•) *Insignificant* **Factor C** 1.0

Comment

3.4 Pounding Potential

(Estimate D1 and D2 and set D = the lower of the two, or 1.0 if no potential for pounding, or consequences are considered to be minimal)

a) Factor D1: - Pounding Effect

Note:
Values given assume the building has a frame structure. For stiff buildings (eg shear walls), the effect of pounding may be reduced by taking the coefficient to the right of the value applicable to frame buildings.

Factor D1 For Transverse Direction: 1.0

Table for Selection of Factor D1	Severe	Significant	Insignificant
Separation	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Alignment of Floors within 20% of Storey Height	( ) 1	( ) 1	(•) 1
Alignment of Floors not within 20% of Storey Height	( ) 0.4	( ) 0.7	( ) 0.8

Comment

b) Factor D2: - Height Difference Effect

Factor D2 For Transverse Direction: 1.0

Table for Selection of Factor D2	Severe	Significant	Insignificant
	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Height Difference > 4 Storeys	( ) 0.4	( ) 0.7	( ) 1
Height Difference 2 to 4 Storeys	( ) 0.7	( ) 0.9	( ) 1
Height Difference < 2 Storeys	( ) 1	( ) 1	(•) 1

Comment

Factor D 1.0

3.5 Site Characteristics - *Stability, landslide threat, liquefaction etc as it affects the structural performance from a life-safety perspective*

Effect on Structural Performance ( ) *Severe* ( ) *Significant* (•) *Insignificant* **Factor E** 1.0

Comment

3.6 Other Factors - *for allowance of all other relevant characterstics of the building*

For ≤ 3 storeys - Maximum value 2.5
otherwise - Maximum value 1.5.
No minimum.

Factor F 2.50

Record rationale for choice of Factor F:

Seismic capacity calculation of the key elements of the structure indicated a capacity greater than 34%NBS

3.7 Performance Achievement Ratio (PAR)
(equals **A x B x C x D x E x F**)

PAR
Transverse 2.50

Initial Evaluation Procedure (IEP) Assessment - Completed for GWRL

Street Number & Name:	Waterloo Interchange (Hutt Central) Railway Station	Job No.:	708533
AKA:	Walterloo Station	By:	s7(2)(a) [redacted]
Name of building:	Waterloo Station Subway	Date:	1/09/2015
City:	Hutt Valley	Revision No.:	A

Table IEP-4 Initial Evaluation Procedure Steps 4, 5, 6 and 7

Step 4 - Percentage of New Building Standard *(%NBS)*

		Longitudinal	Transverse
4.1	**Assessed Baseline *%NBS (%NBS)*$_b$** (from Table IEP - 1)	17%	17%
4.2	**Performance Achievement Ratio (PAR)** (from Table IEP - 2)	2.50	2.50
4.3	**PAR x Baseline *(%NBS)*$_b$**	45%	45%
4.4	**Percentage New Building Standard *(%NBS)*** (Use lower of two values from Step 4.3)		45%

Step 5 - Potentially Earthquake Prone? (Mark as appropriate) — *%NBS* $\leq$ 34: **NO**

Step 6 - Potentially Earthquake Risk? (Mark as appropriate) — *%NBS* < 67: **YES**

Step 7 - Provisional Grading for Seismic Risk based on IEP

Seismic Grade: **C**

Additional Comments (items of note affecting IEP score)

1. No drawing is available. Date of construction is assumed to be the same as those in Epuni, Naenae and Taita Subways, which were 1950's.

Relationship between Grade and *%NBS* :

Grade:	A+	A	B	C	D	E
%NBS:	> 100	100 to 80	79 to 67	66 to 34	33 to 20	< 20

WARNING!! *This initial evaluation has been carried out solely as an initial seismic assessment of the building following the procedureset out in the New Zealand Society for Earthquake Engineering document "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes, June 2006". This spreadsheet must be read in conjunction with the limitations set out in the accompanying report, and should not be relied on by any party for any other purpose. Det ailed inspections and engineering calculations, or engineering judgements based on them, have not been undertaken, and these may lead to a different result or seismic grade.*

Initial Evaluation Procedure (IEP) Assessment - Completed for GWRL

Street Number & Name:	Waterloo Interchange (Hutt Central) Railway Station	Job No.:	708533
AKA:	Walterloo Station	By:	[redacted]
Name of building:	Waterloo Station Subway	Date:	1/09/2015
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Table IEP-5 Initial Evaluation Procedure Step 8

Step 8 - Identification of potential Severe Critical Structural Weaknesses that could result in significant risk to a significant number of occupants

8.1	Number of storeys above ground level	1
8.2	Presence of heavy concrete floors and/or concrete roof? (Y/N)	Y

Occupancy not considered to be significant - no further consideration required

IEP Assessment Confirmed by ____________________ **Signature**

[redacted] **Name**

CPEng. No

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