Cross Valley Link

Seismic Resilience Philosophy

Prepared for

New Zealand Transport Agency Waka Kotahi (NZTA)

Prepared by

Tonkin & Taylor Ltd

Beca Ltd

Commute Transportation Consultants Ltd

May 2025

P2G.RPT.DM.1058.1

Document Control

Title: Cross Valley Link Seismic Resilience Philosophy

[redacted]

S7(2)(b)(i)

Contents

1 Introduction

1.1 Application of the document

This draft Seismic Resilience Philosophy (SRP) has been prepared in accordance with the requirements of Section 2.3.1.2 of the NZTA Roads of National Significance Standardised Designs document (RoNS Standard)[2].

This **draft** SRP outlines the agreed design life, Importance Levels and return periods for seismic design events used in the development of the scope and costs for the Cross Valley Link (CVL) Investment Case. Further detail will be required in future stages of the project to fully document the minimum requirements and design criteria.

This document should be read in conjunction with the CVL Project Scope and Outcome Philosophy Statement (PSOPS).

1.2 Alignment with RoNS Standard approach

This SRP is generally aligned to the risk-displacement based philosophy set out in the NZTA Bridge Manual (BM)[1]. However, this SRP sets out several key Departures to the approach outlined in section 2.3.1.2 of the RoNS Standard[2] and the BM[1].

The seismic demands set out in the BM[1], when applied with recent changes in the seismic hazard[3] create affordability challenges for structures constructed on the CVL corridor because of the liquefaction and lateral spreading expected. The modifications set out in this SRP are considered essential to meet the project affordability threshold, while appropriately mitigating the seismic risk.

1.3 Summary

A departure is proposed in this SRP to achieve more cost-effective solutions that align with the project objectives set out in the PSOPS. In summary:

- Importance Levels are modified to align with the project objectives and project resilience philosophy.
- New structures will be in general accordance with Chapter 5 of the BM but with some additional clarification on expected post-earthquake performance as set out in this document.
- Soil structures will not strictly achieve the performance criteria set out in Chapter 6 of the BM. Alternatives are proposed that focused on cost effective post-earthquake function and cost-effective reinstatement.

2 Overarching Seismic Resilience Philosophy

The SRP is aligned to the CVL project objectives (refer PSOPS) which focus on transport resilience to high likelihood events. The seismic resilience therefore focusses on a low impact to the network in high frequency seismic events.

[1] NZTA Bridge Manual SP/M/022 Third Edition Amendment 4.
[2] Waka Kotahi NZTA Standardised design solutions for use on State Highway Roads of National Significance, August 2024 v2.0.
[3] GNS 2022 National Seismic Hazard Model.

2.1 Design performance under high-frequency seismic events

The performance of structures and slopes under high frequency earthquake events shall have a low impact on the network. Design under high frequency events shall focus on the robustness of the network, speed of repair and minimising maintenance costs through consideration of access and material selection.

On this basis, a relaxation of the Serviceability Limit State and Operation Continuity Limit State performance requirements set out in the BM is proposed with a philosophy that is focussed on rapid repairs and minimal network disruption following high frequency earthquake events.

2.2 Design performance under low-frequency seismic events

The performance of structures subject to low frequency earthquake events shall be conditioned to safeguard life safety and post event functional principles, noting that structural damage and large ground displacements may be expected.

The seismic design philosophy is focused on:

- Collapse avoidance of structures.
- Post earthquake function of the structures and route (minimising disruption).
- Ease and cost efficiency of reinstatement.
- Life safety in accordance with the NZ Building Act.

To efficiently (and affordably) achieve the above objectives, the design will focus on more flexible and movement tolerant structures wherever the geometry and site conditions allow. These structures, by their intended nature and form, are unlikely to meet the displacement limits prescribed in the BM. The SRP will therefore depart from the prescribed limits for these low frequency events.

2.3 Affordability of post-earthquake repairs

As defined in the RoNS Standard[2], the design process shall focus on the advantages and potential cost savings presented by the adoption of low-damage solutions.

This is further defined in this SRP as an appropriate choice of materials and products and use of redundancy. Ductility of the structural elements and the cost and time to reinstate the network after an earthquake event will be considered with a focus on affordability of works to reinstate operability and resilience after an earthquake.

2.4 Existing Infrastructure

There is no requirement to upgrade the design life or performance of any existing structures or slopes beyond the performance needed to achieve the requirements of this SRP.

3 Overarching Design Approach

3.1 Regulatory Framework

For all elements of the project, the seismic design must give effect to the requirements of the Resource Management Act 1991, the Building Act and the Health and Safety at Work Act.

3.2 Standards and guidelines

Seismic designs shall be undertaken in accordance with the following key standard documents unless otherwise modified by this SRP. The design criteria and/or Minimum Requirements should define the specific document and version of each in later stages of design.

i NZTA Bridge Manual.

ii NZTA Standard Specifications and Guidelines.

iii New Zealand Standards.

iv Australian Standards and Specifications.

v NZTA Technical Advice Notes.

4 Seismic Design Criteria

4.1 Seismic Hazard

The GNS National Seismic Hazard Model 2022[3], with median ground shaking at the appropriate AEP event may be used in lieu of a SSSHA required by Cl 5.2.5 of the BM. The SSSHA will primarily adopt the outputs from the 2022 NSHM as it represents the current best understanding of the seismic hazard.

4.2 Design Life

A design life of 100 years shall be adopted in accordance with the BM for the assessment of the seismic performance.

4.3 Level of Services and Importance Levels

The Importance Levels (IL) set out in Table 1 are in general accordance with NZS1170:2002 and are aligned to the overarching project objectives and resilience outcomes. The assignment of Importance Level with respect to the estimated construction cost of a structure shall not apply[4].

NOTE: The proposed IL's are a departure from Table 2.1 of the BM as are the AEP's assigned to these Importance Levels in Section 4.4.

Table 1: Importance Level

Structure type	One Network Framework classification	Importance Level (IL)
New structures (abutting or impacting SH2 corridors)	Interregional connectors[5]	3
New bridge structures (not impacting SH2)	Urban Connector[6]	2
Earth retaining systems (Retaining Walls) (not impacting SH2)	Urban Connectors[6]	2

[4] Technical Advice Notice #24-01.
[5] This is the existing route classification for State Highway 1 and 2.
[6] Classification is in accordance with the NZTA One Network Framework confirmed by Chief Engineer's Advisory Group (CEAG) in meeting 31/1/25.

Structure type	One Network Framework classification	Importance Level (IL)
Soil Structures including slope support structures	Urban Connectors[6]	

4.4 Annual Exceedance Probabilities for Seismic design actions

The Annual Exceedance Probability (AEP) design actions for earthquake shall be determined from Table 2.

Table 2: Seismic Annual Exceedance Probability

	Design Seismic AEP		
Importance level[7]	**IL1**	**IL2**	**IL3**
SLS	1/25	1/50	1/50
DCLS	1/100	1/175	1/250
CALS	1/250	1/500	1/500**Error! Bookmark not defined.**

NOTE: The proposed probabilities are a departure from Table 2.1 to Table 2.3 of the BM.

4.5 Seismic Performance

The performance of structures (including soil structures) under different seismic events shall be as set out in Table 3. Further definition on the expected displacement (and proposed displacement limits) will need to be documented during subsequent design stages and incorporated within later versions of this document and /or the final draft of the project MRs (and would be subject to NZTA final review).

4.5.1 General performance under SLS and OCLS events

Seismic-SLS and OCLS induced displacements need not meet the limits prescribed in the BM provided the overarching philosophy set out in this document can be demonstrated.

SLS requirement of Table 5.1 of the BM for “no damage to primary structural members” shall be interpreted as the primary member design actions to be less than member design capacity derived using the probable material strengths from Table 5.7 of the BM and a strength reduction factor of 1.0. Crack limits shall not apply under SLS seismic loading.

Ground deformations, and associated performance of soil structures (including cut and fill slopes as defined by the BM) shall be assessed and treated in accordance with the impact on the road network and ease of repair and/or reinstatement of the effected asset. A reduction in the level of service expected following SLS earthquake events is proposed.

A summary of general performance expectation is set out in Table 4.

[7] This is the Importance level as defined in Section 4.3 of this SRP which is a Departure from the BM.

NOTE: The proposed performance under SLS and OCLS events is a departure from Tables 6.1, 6.2 & 5.1 of the BM.

4.6 General performance under DCLS and CALS events

The performance of structures subject to DCLS and CALS-level earthquake shall be conditioned to safeguard life safety principles and post-earthquake function. Seismic-DCLS induced displacements need not meet the limits prescribed in the BM provided the overarching philosophy set out in this document can be demonstrated.

A summary of performance expectation is set out in Table 3.

NOTE: The proposed performance under SLS and OCLS events is a departure from Tables 6.1, 6.2 & 5.1 and sections 6.1.2a & 6.6.9 of the BM.

4.7 Bridge performance philosophy

Standard bridge design solutions complying in full with the BM have proven to be unaffordable (refer Section 1.2). Due to the extreme seismicity of the region, the Hutt River bridge foundation approaches will need to be flexible with structural spans able to be repositioned following large earthquake events.

Seismic resilience is expected to align with best value for the CVL project through the use of movement tolerant bank seats founded on reinforced soil structures for the Hutt River bridge. Deformation of the abutments can be expected to still maintain stability of the bridge structural spans with improved post-earthquake function in the DCLS and CALS events. An attempt to meet the requirements of the BM through robust, rigid structural elements with high-cost repair of ductile concrete elements is expected to provide low value and less resilient solutions for NZTA.

The ground under the Hutt River bridge abutments (and piers) is likely to need to be improved to limit seismically triggered lateral spread and vertical settlements to levels that can be accommodated by the bridge and achieve the performance limits set out in this SRP.

Table 3: Minimum Performance Requirements

Seismic Event		Resilience Philosophy for Design	Acceptable Performance
High Frequency	**Serviceability Limit State** Moderate earthquake event with localised liquefaction and lateral spreading possible at interchanges and CVL corridor.	Minor damage of structures (including soil structures as defined in the BM) with minimal and short duration disruption to traffic. Minimise cost of repairs to achieve full capacity.	Departures from BM (Table 6.1, 6.2 & 5.1) to focus on and permit: • Soils structures (including bridge abutment) displacements in the order of 100 mm vertical and lateral movement. • Instability in unsupported cut slopes allowable up to the IL1 level of service threshold set out in Table 2.2 of this SRP.
	Operational Continuity Limit State Large earthquake event with localised liquefaction and lateral spreading likely at interchanges and CVL corridor.		Departures from BM (Table 6.1, 6.2 & 5.1) to focus on and permit: • Displacements as for SLS performance. • Partial access in 24 hours. • Full access in several weeks rather than 24 hours.
	Damage Control Limit State Major earthquake with widespread liquefaction and lateral spreading at interchanges and CVL corridor	Moderate damage to structures (including soil structures as defined in the BM) with repairs feasible for: • Emergency traffic within 3 days and • Long term permanent repair to carry full traffic loading and DCLS event.	Departures from BM (Table 6.1, 6.2 & 5.1) to align with agreed philosophy and permit: • Bridge abutment displacement in the order of 300 mm vertical and 500 mm lateral movement. • No specified limit on displacements of other soil structures provided post-earthquake resilience philosophy can be demonstrated.
Low Frequency	**Collapse Avoidance Limit State** Significant earthquake with extensive local fault rupture possible and associated ground displacement.	Significant damage to structures (including soil structures) with a focus on: • Life safety to meet the Building Code. • No collapse of bridges and retaining structures supporting the carriageway. • Foreseeable for route to be usable by emergency traffic within reasonable timeframe	Departures from BM (S6.1.2a & 6.6.9) for structures to focus on • No collapse of key structures. • Bridges may be usable by emergency traffic with temporary propping or structural repair within 1 month.