

# Civil Engineering Standard

# Retaining Walls

## Purpose

This document specifies the design requirements for retaining walls on the KiwiRail network

## Document Control

<b>Document No.</b>	C-ST-RW-4104	<b>Issue No.</b>	Issue 1.0
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<b>Prepared (P) Reviewed (R) Amended (A)</b>		<b>Checked and Approved By</b>	Civil Engineering – Technical Committee
		<b>Authorised for Release By</b>	Professional Head – Civil Engineering

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## Disclaimer

KiwiRail would like to gratefully acknowledge support from Railcorp, who have permitted material from their standards to be incorporated in this document.

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# 1. Revision Procedure and History

This is a 'living' document, that will be up dated every five years or whenever KiwiRail determines that changes to it and processing requirements documented herein are appropriate.

If changes arise from the review this document will be reissued, however, if no changes arise from the review, the current version of this document will remain in force.

Refer to the **Briefing Note(s) for C-ST-RW-4104 Retaining Walls**

and **Document History** (at the end of this document) for full document changes.

Issue No	Prepared (P) Reviewed (R) Amended (A)	Authorised for Release By	Date Effective

## 1.1 Changes in this issue

Issue No	Section	Description	Page(s)

## 1.2 Withdrawn, closed and superseded

Old Reference	Title	Replaced by

# 2. Associated Documents

## 2.1 KiwiRail documents and drawings

Level	Number	Title
1	G-PO-AL-9000	Infrastructure Engineering Policy
2	G-PR-AL-9002	Infrastructure Engineering Principle
2	C-PR-GN-4011	Civil Engineering Principle
3	C-ST-CD-4102	Corridor Drainage
3	C-ST-CU-4103	Culvert
3	C-ST-GE-4105	Ground Engineering
3	C-ST-RP-4106	River Protection
3	C-ST-CP-4107	Coastal Protection
3	C-ST-TU-4108	Tunnel
3	C-ST-PL-4109	Platform
3	C-ST-FO-4110	Formation
3	C-ST-GN-4111	Civil Compliance

Level	Number	Title
3	C-ST-GN-4115	Civil Engineering Inspection
3	C-ST-GN-4117	Civil Engineering Audit
	T003	Track Code
	T200	Track Engineering Handbook
	W004	Structures Code
	W200	Structures Inspection Manual
	W201 (Issue 6)	Structures Railway Bridge Design Brief
3	E-ST-AE-0101	AEA Earthing and Bonding Design Standard
	DWG 100862	Drainage and Formation Standard Detail Drawings

## 2.2 New Zealand and International Standards

The design of retaining walls shall comply with this standard and relevant New Zealand Standards and codes. Other international standards may be referred to for guidance where specific information is not available in the referenced standards.

Where any discrepancy exists between the different standards, the Professional Head Civil Engineering, shall be consulted to provide a ruling on applicability.

For earthworks standards, refer to Ground Engineering and Earthworks Standard, C-ST-GE-4105.

The principal design standards are listed below. Refer on line for the latest editions. The designer is expected to refer to other specific specifications as required, for example NZS 3113 Specification for chemical admixtures for concrete.

### New Zealand Standards

NZTA SP/M/022	New Zealand Transport Authority Bridge Manual
NZS 3101	Concrete structures standard
NZS 3109	Specification for concrete construction
NZS 3112	Methods of test of concrete
NZS 3114	Specification for concrete surface finishes
NZS 3404	Steel structures standard
NZS 3603	Timber structures standard
NZS 4402:1986	Methods of Testing Soils for Civil Engineering Purposes
TNZ F 1 (1997)	Specification for Earthworks Construction

### Joint Australia/New Zealand Standards

AS/NZS 1170.0	Structural design actions Parts 0, 1, 2, 3 and 5
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AS/NZS 4671      Steel reinforcing materials

### **Australians Standards**

AS 2159            Piling - Design and Installation

AS 3600            Concrete Structures

AS 4678            Earth Retaining Structures

AS 5100.3         Part 3: Foundations and Soil-Supporting Structures

### **Other Standards and Guidelines**

BS 8006-1:2010   Code of Practice for Strengthened/Reinforced Soils and Other Fills

BS 8006-2:2011   Code of Practice for Strengthened/Reinforced Soils. Soil Nail Design

BS 8002:2015     Code of Practice for Earth Retaining Structures

BS 8081:2015     Code of Practice for Grouted Anchors

## **2.3 Statutory requirements**

Statutory documents which should be referred to include, but are not limited to, the following New Zealand Statutory Requirements:

- The Railway Act 2005
- The Building Act
- The Building Regulations and Building Codes
- Health and Safety at Work Act 2015 and Regulations
- Code of Practice for Safety in Excavations and Shafts for Foundations
- Compliance Document for New Zealand Building Code Clause B1, Structure
- Compliance Document for New Zealand Building Code Clause B2, Durability
- Plumbers, Gas Fitters and Drain Layers Act
- Resource Management Act 1991
- Territorial and Regional Authority Policy and Bylaw documents as appropriate

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### 3. Acronyms and Definitions

Acronyms	Definition
AS	Australian Standards
AREMA	American Railway Engineering and Maintenance-of-way Association
NZS	Standards New Zealand
NZTA	New Zealand Transport Agency

#### 3.1 Notes, caution and warnings

Icon	Definition
	Note(s) to point out something of special importance
	Caution or warning – drawing special attention to anything of important reminder or a safety message

## 4. Scope

The purpose of this document, Civil Engineering Standards - Retaining Walls, is to define the design requirements for retaining walls as permanent works. This document shall be read in conjunction with the Civil Engineering Policy and Principle Standards.

The types of retaining walls covered in this document includes:

- Cantilevered wall (eg reinforced concrete, sheet pile, etc).
- Gravity wall (eg reinforced concrete, gabion, crib, etc).
- Reinforced soil wall (eg reinforced earth/mechanically stabilized earth, soil nail).
- Soldier pile walls.

These following items are excluded from the scope of this standard:

- Masonry retaining walls.
- Temporary retaining walls.
- Retaining structures (eg wing walls) linked to a bridge.

The Professional Head – Civil Engineering is the first point of contact and shall be consulted for any design clarifications.

### 4.1 Use in the field

This document has been designed to be used in the field. It is expected that this document will be opened in an iPad via 'Briefcase' and used as reference to complete the task. Note as written on the front cover the controlled version is held on SharePoint. **Printed copies of this document are uncontrolled.**

## 5. General Requirements

### 5.1 Design standards

All retaining wall structures shall be designed to the NZTA Bridge Manual, the relevant Standards listed in section 2 and the requirements of this Standard.

The designer shall take into account requirements for services and utilities, drainage and public safety.

### 5.2 Safety-in-design

A Safety-in-Design (SiD) register shall be recorded and submitted to KiwiRail for all designs. The designers are accountable for a 'safe design' for all assets. A safe design means the implementation of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risk to health and safety throughout the life of the structure that is being designed.



Safety-in-design principles shall also apply to the refurbishment of existing structures. The designer shall take into account safety considerations for construction and maintenance personnel, and the future users of the structure.

Provision shall be made for a safety handrail on top of a retaining wall where the height difference between the top of wall and base of the drop level exceeds one metre. The safety handrail on retaining walls may be omitted subject to a risk assessment and consultation with, and approval from, the Professional Head – Civil Engineering. An example of a situation where an exemption is likely to be granted is where the embankment adjacent to the retaining wall presents an equivalent risk and is not protected.

## **5.3 Existing structures**

### **5.3.1 Inspection and management of existing sub-standard structures**

The inspection of existing retaining wall structures shall be carried out in accordance with KiwiRail Standard W200: Structures Inspection Manual.

The Professional Head – Civil Engineering, shall be notified when a sub-standard structure has been identified. Management of the identified sub-standard structure shall be recorded for on-going monitoring and managed as per KiwiRail business processes.

### **5.3.2 Replacing or refurbishing existing structures**

When replacing or refurbishing an existing retaining wall, the design shall comply with section 5.1 and provide for the current and proposed future line usage and business requirements.

In some circumstances it may not be feasible to achieve complete adherence to the required codes due to site or other constraints. In such cases, the post-refurbishment residual shortcomings of the structure should be fully noted and an exemption sought from the Professional Head – Civil Engineering.

Reconstruction or refurbishment work must consider the requirements of all stakeholders. Design options must consider the following requirements, but not limited to:

- general safety
- track geometry and adjacent clear distance
- impact on track maintenance and renewal activities
- current and future rolling stock types
- drainage
- service conduits
- removal of trees
- heritage issues
- potential impact on surrounding/existing buildings and structures
- potential impact on landscape or amenity issues

- potential impact on signal sighting or signal positioning
- safe removal of existing/defective structures
- safety in design
- constructability.

## 5.4 Protection of the environment

The design of retaining walls including the refurbishment of existing structures shall take into account environmental impacts during construction and maintenance activities, with a view to minimising any such impacts.

Guidance on techniques for minimising erosion and managing sediment runoff from construction activities are outlined in the NZTA Erosion and Sediment Control Guidelines – Construction Stormwater Management (2014). Local Authorities also have guidelines that should be reviewed and adopted as required.

In some circumstances, an Erosion and Sediment Control Plan and/or a Resource Consent may be required. Advice should be sought from KiwiRail Resource Management advisors.

## 5.5 Documentation and records

Retaining wall drawings must comply with KiwiRail standard procedures and formats, and must detail the design criteria including loading, horizontal and vertical clearances, and any other information that is relevant to ensuring that the structure is constructed and maintained in accordance with the design.

Appropriate documents must be prepared at the following stages:

- Investigation and planning
- Design and specification and
- Construction.

Documentation is an important consideration in all projects. The relevant documents should include:

### 5.5.1 Design and specification

The functional requirements of the design must be documented in the specification and drawings. The documentation must be sufficiently complete to allow the constructor to carry out the works, and for those supervising to be able to interpret the design and administer the works

Reference should be made to KiwiRail requirements for documenting of geotechnical testing – KiwiRail Task Instruction for Geotechnical Investigation Requirements CT-TI-GE-4201.

### 5.5.2 Drawing standards

Construction drawings must comply with the KiwiRail standard procedures and formats, and must detail the design criteria including loading, horizontal and vertical clearances, and any other relevant information to ensure that the new structure is constructed and maintained in accordance with the design.

### 5.5.3 Construction

Adequate records need to be kept during construction, including conditions encountered, works as executed, as built drawings, testing records and any alterations to the specification and drawings.

Site records, such as daily diaries and detailed drawings of works as executed, should be maintained by site staff to a level of detail appropriate for the scale of the works.

## 5.6 Heritage

Heritage considerations and classifications must be observed in all retaining wall designs. This may have particular application in circumstances where an existing historically significant structure is being refurbished or modified, or where a new structure is being proposed in the vicinity of existing heritage items.

In all instances, safety is the main priority and unsafe structures/components should be replaced if they do not satisfy the KiwiRail requirements for the safe running of trains.

Where required, advice on heritage and archaeological values can be sought from KiwiRail's Resource Management specialists.

## 5.7 Maintenance

The design of retaining walls including the refurbishment of existing structures shall take into account the ability to access components for inspection and maintenance purposes.

Materials and finishes should be chosen to minimise future maintenance due to the close proximity of the structure to the tracks and commuter usage. Galvanised or stainless steel fasteners shall be specified, where access for inspection and replacement purposes is difficult, depending on the exposure classification of the site. Isolation of dissimilar metals must be considered.

Maintenance requirements must be specified in the design documentation for structures. In most cases, KiwiRail's inspection frequencies in accordance with W004 Structures will apply and shall be considered in the design. However site specific maintenance requirements may need to be provided for approved cases and any exemption shall be documented on the construction drawings. Requirements must include examination tasks and frequencies, damage limits, and repair standards.

## 5.8 Electrical requirements

For new work in electrified areas and those with high likelihoods of being electrified in future, designs shall provide for earthing and bonding of metallic components on retaining walls to mitigate touch potential hazards and corrosion of steel.

The design strategy must include giving consideration to 'designing out' earthing and bonding issues by separation and isolation of metallic structures. Where this is not possible, the design must achieve an appropriate balance of the risks associated with touch potentials and with corrosion due to stray currents.

The electrical design requirements are:

- 1) Overhead wiring structures on retaining walls must be bonded via a spark gap.
- 2) Metallic components attached to the retaining wall must be insulated from the retaining wall structure.
- 3) Utility services, such as water, gas, communications and lights, must be insulated from the retaining wall.
- 4) Insulation panels are required in fences on retaining walls to prevent transfer of potential stray current.

## 6. Design Criteria

Unless otherwise noted, the design requirements for all retaining walls, such as design life, durability etc, shall be in accordance with KiwiRail Civil Engineering Policy/Principle.

### 6.1 General retaining walls

Retaining walls should be designed for a 100 year design life. Note that neither timber walls nor gabion baskets can meet this requirement. Both are none-the-less allowed in specific situations.

All retaining walls and reinforced-earth structures  $\geq 1.5\text{m}$  high must be designed by a suitably experienced chartered engineer and shall comply with the relevant standards listed in section 2. Retaining walls less than 1.5m high, subject to direct rail loading or surcharge loads shall likewise be designed by a suitably experienced chartered engineer.

Live loads on retaining walls shall be designed in accordance with:

- The KiwiRail W201 Railway Bridge Design Brief when subjected to rail live load
- AS/NZS 1170 when not subjected to rail live loads, or
- Instructions from the Professional Head – Civil Engineering.

The requirements for the deformation limits of walls subject to rail loading must be assessed and the limits shall be discussed and agreed with the Professional Head – Civil Engineering.

The design of soil-supporting structures for bridges is not covered by this standard but reference should be made to the applicable Structures Engineering Standard.



**Figure 6:1 Rail and timber retaining wall - MNPL 44.2Km Westmere Bank, Whanganui**



**Figure 6:2 Steel piles retaining wall - JVILL 2.5Km Wellington**

The designer is accountable for ensuring that the retaining wall design has sufficient robustness and redundancy. The structure shall not suffer a disproportionate collapse in the event of an impact load from train derailment. A risk assessment must be undertaken in consultation with the Professional Head – Civil Engineering in order to eliminate or minimise the risk as reasonably practicable.

Sharp or perpendicular returns at the end of retaining walls shall be avoided. Instead, the walls shall be flared away from an oncoming carriageway.

The use of large (high) gabion retaining structures to support rail embankments is discretionary only based on direct consultation with and agreement from the Professional Head – Civil Engineering. Where permitted, dual anticorrosion measures (hot dip galvanising plus PVC coating) together with heavy gauge wire must be specified.



**Figure 6:3 Gabion basket wall - NIMT 322.3Km – Ohakune**

The validity of incorporating the effect of the top one metre of passive fill in front of a retaining wall must be evaluated on the basis of a risk assessment. The results must be presented to the Professional Head – Civil Engineering for approval. The passive resistance of shear keys may, however, be routinely included.

For cantilevered piled walls, the effect of the passive fill in front of the wall to a depth of 1.5 times the pile diameter must be ignored, and 3.0 times the diameter on ground sloping more than 15 degrees.

In cuttings, undertrack retaining walls within three metres of a track centreline, shall have a minimum of 1.0m clearance above the top of the foundation to top of rail to permit uninhibited passage and functioning of any cess drain or sub-surface drain, including future ballast cleaning and track reconditioning activities.

Standard retaining wall types should be referenced as appropriate including those referred to in 'Investigation and Construction of Rail Iron Retaining Walls' Task Instruction C-TI-RW-4203 Investigation and Construction of Rail Iron Retaining Walls.

## 6.2 Ground anchors

Ground anchors, when a structural part of a retaining wall, shall have a design life of 100 years and shall comply with the requirements of the relevant standards listed in section 2, in particular AS 4678: 2002 Earth Retaining Structures and BS 8081:2015 Code of Practice for Grouted Anchors.

The design of ground anchors shall include mitigation against the effects of stray currents in electrified areas.

The designer must specify the requirements for testing, installation and long term monitoring, if any, for the ground anchors on the construction drawings. These requirements must be submitted to the Professional Head – Civil Engineering for approval during the design process.



Figure 6:4 Anchor testing NIMT 453.6Km

### 6.3 Reinforced earth (soil nailing, MSE walls)

Soil nailing must comply with the requirements of the relevant standards listed in section 2.



Figure 6:5 Soil nailing - MSL 366.7Km Port Chalmers

### 6.4 Geotechnical requirements

All retaining wall designs shall take into account site-specific geotechnical parameters.

Where information is limited or insufficient, geotechnical investigation shall be undertaken by the designer to determine the site parameters. Geotechnical

Investigations shall be done in accordance with Civil Engineering Task Instruction C-TI-GE-4201 Geotechnical Investigation Requirements.

## 6.5 Drainage requirements

All retaining wall designs must include appropriate provision for back-of-wall drainage (eg drainage layer, collector pipes and weep holes). Discharge points for drainage shall need to be site specific, and not compromise the stability of other structures or adjacent track formation. Further reference should be made to the Civil Engineering Corridor Drainage Standard, C-ST-CD-4102, for additional details on acceptable drainage practices in locations around retaining wall assets.

## 6.6 Other requirements

### 6.6.1 Movement joints

Provision shall be made in new concrete retaining walls for the control of cracking caused by shrinkage and thermal effects.

Movement joints must be designed to accommodate both contraction and expansion. Design must be in accordance with the relevant standards in section 2.

Horizontal construction joints are not allowed in walls, except at the joints in between the slab and wall.

Movement joints must be provided around fixed objects located in slabs, for example structure footings, to prevent damage to the slab.

### 6.6.2 Mechanical and chemical anchors

Mechanical and chemical anchors may be used to attached minor structures to the retaining wall unless the anchors are subject to sustained tension.

The construction drawings shall specify the relevant design requirements and installation criteria in accordance with the manufacturers' specifications.

The designer must take at least the following into consideration in the design when mechanical and chemical anchors into existing structures are specified:

- Load carrying capacity of the structure.
- The age and condition of the structure.
- The material/grade of the structure.

## 7. Construction

Appropriate construction specifications must be incorporated in the design and construction documentation of retaining walls.

The design of retaining walls including the refurbishment of existing structures must take into account construction constraints, particularly live rail operating conditions, track Block of Line constraints and physical access limitations.



## 7.1 Earthworks

Earthworks associated with the backfill to retaining walls must be designed in accordance with the relevant standards in section 2 for compaction and drainage.

## 7.2 Approved materials

Approved construction materials for main structural elements are concrete and steel for new and refurbished structures.

Timber is acceptable for retaining walls not carrying rail loads or for specifically approved walls. Where utilised, timber retaining walls shall be no higher than three metres unless an exemption is obtained from the Professional Head – Civil Engineering. All timber members shall be H5 treated. In marine environments, timber members require grade H6 treatment.

## 7.3 Formworks

Permanent formwork may be used in the design of retaining walls, but it must not be structurally significant. The design of steel permanent formwork must include mitigation for the effects of stray currents.

## 7.4 Surface finishes

For urban areas or high public visibility locations, designers must consider aesthetic factors when selecting the form and finishes of retaining walls.

At locations where vandalism may be an issue, walls must have an anti-graffitti coating applied.

## 8. Clearances

Horizontal and vertical clearances for retaining walls must comply with the KiwiRail T200 Network Engineering Track Handbook - Figure 2 and Figure 3 Fixed Structures Gauge as well as allowance for versine and end throws on curves.

The area extending one metre below the rail level of the Fixed Structures Gauge as detailed in T200 Figure 2 and Figure 3 must be kept clear of structures and structure footings.

Requirements for trackside drainage should also be considered, especially for retaining walls directly upslope of the rail line. Where drainage is required, additional clearances for drains should be allowed for as per standard cess drains (type A drains) from 'Drainage & Formation Standard Detail' drawing set 100862, unless otherwise agreed with the Professional Head – Civil Engineering.

## Briefing Note(s) for C-ST-RW-4104 Retaining Walls

Date Effective

30/06/2016

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Issue 1.0

### Background

[Click here to enter text.](#)

### Key changes / compliance

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### Implementation

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Applicability (Select relevant boxes)	General	Civil	Signals and Telecommunications	Structures	Track	Traction and Electrical
Zero Harm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Learning and Development	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Project Management Office	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Manager Property Revenue and Grants	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
National Train Control Centre	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Engineering Services Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
National Supply Chain and Distribution Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Professional Head		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Network Services Managers		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Region Operations Managers		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
STTE Managers		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Production Managers		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Asset Engineers		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Document History

**Note** page numbers relate to the document at the time of amendment and may not match page numbers in current document.

Issue No.	Section	Description	Page(s)