SCIRT Rebuilding Infrastructure

LEARNING LEGACY

Lessons learned from one of New Zealand's most challenging civil engineering projects: rebuilding the earthquake damaged pipes, roads, bridges and retaining walls in the city of Christchurch 2011 - 2016.

Pipe Lining Specification

Story: Pipe Lining

Theme: Construction

A document which specifies the technical requirements for the rehabilitation and repair of pipes using lining methodologies during the SCIRT programme of work.

This document has been provided as an example of a tool that might be useful for other organisations undertaking complex disaster recovery or infrastructure rebuild programmes.

For more information about this document, visit www.scirtlearninglegacy.org.nz

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Specification for Pipe Lining

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Contents

Appendices

Revision History

Revision	Date	Name	Brief Description
1	13 Nov 2012	Peter Carter	Original
2	11 Jul 2013	Philip McFarlane	General revision; pre-approval process added
3	25 Jul 2013	Tony Gordon	Serviceability section modified
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9	21 Nov 2014	Tony Gordon	Additional clarifications; update to traffic loading
10	27 May 2016	Tony Gordon	Change to post-lining CCTV requirements; minor text edits

Note: changes between the previous and current revisions are marked by a line in the right margin

Glossary

Abbreviation	Description
AS	Australian Standard
ASTM	American Society for Testing and Materials
CCC	Christchurch City Council
CCTV	Closed Circuit Television
CIPP	Cured in Place Pipe
CSS	Construction Standard Specification
IP	Infiltration at Pipe Wall
ITP	Inspection and Test Plan
LJR	Lateral Junction Repair
NDSR	No Dig Spot Repair

4 Specification for Pipe Lining

4.1 General

This document covers:

- Technical Specification for the rehabilitation and repair of existing pipes and laterals using:
  - Cured in Place Pipe (CIPP) lining, which is cured either by ambient cure or by circulating hot water or introducing controlled steam within the tube
  - Lining with spiral-wound profile strip, with or without grouting
  - No Dig Spot Repair (NDSR) patching using CIPP
  - Lateral Junction Repair (LJR) patches
  - Folded PVC lining (for pipes DN375 and smaller only)
- Deliverables
- Testing and inspection

This Specification does not apply to rehabilitation of pipes that are not circular.

This Specification does not cover Cured in Place Pipe (CIPP) lining that is cured by UV light. This does not necessarily preclude the use of UV-cured systems. However, their use will be assessed on a case by case basis and additional specification clauses may be applied to cover specific design or installation considerations.

Sections 4.2 to 4.8 outline general specification requirements that apply to all rehabilitation systems. Sections 4.9 to 4.14 outline further requirements that are particular to certain types of rehabilitation systems. Additional project-specific Information is provided in Section 4 of the project-specific Specification.

Because of the risk of excessive wrinkling, bends over 45 degrees (in any direction) are not to be lined. A consequence of this restriction is that vertical lateral droppers are not to be lined.

4.2 Product Approval and Work Method Submittals

4.2.1 Product Approval Process for Pipes DN375 and Smaller

A technical panel has been established to approve Specialist Lining Contractors and rehabilitation systems for renewal of gravity wastewater and stormwater pipes.

A pre-approved list of Specialist Lining Contractors is maintained. The list details:

- Specialist Lining Contractors who have demonstrated that they are able to undertake works that comply with this specification
- The rehabilitation systems that the Specialist Lining Contractors are approved to install
- The circumstances under which each particular rehabilitation system is approved to be used and any limitations regarding its use

Pre-approved rehabilitation systems can be installed by approved Specialist Lining Contractors without the need to submit further details, other than the statement of compliance outlined in Section 4.6.1, in situations that comply with the details provided in the approved Product Work Statement (which includes the structural design) and that satisfy the circumstances and limitations listed in the pre-approval.

The pre-approval process is described in the 'Approval Process for Pipeline Rehabilitation Contractors and Systems' located in the Project Centre Register.

From time to time, it may be necessary to use rehabilitation systems or variations of systems that have not been pre-approved. In such cases, applications for approval for specific projects can be made using the same process.

Approval of a rehabilitation system does not alter the requirement to comply fully with this Specification.

4.2.2 Product Approval Process for Pipes Larger than DN375

Submit specific details of the rehabilitation system to the Technical Panel for approval before any rehabilitation works are undertaken. The information that is to be submitted is described in the 'Approval Process for Pipeline Rehabilitation Contractors and Systems' located in the Project Centre Register and includes the submission of a Product Work Statement. In addition details are to be provided as how it is proposed to reopen lateral connections after lining and the type of LJR that is proposed to be installed.

In cases where the rehabilitation will be undertaken by a Specialist Lining Contractor, who is using a rehabilitation system that has already been pre-approved for use on pipes DN375 and smaller, the submission may reference the details already submitted where these also apply to rehabilitation of pipes larger than DN375.

Approval of a rehabilitation system does not alter the requirement to comply fully with this Specification.

4.3 Rehabilitation System Requirements

4.3.1 General

The installed rehabilitation system shall have a minimum service life of fifty years under the design conditions detailed in this Specification.

Liners are to be continuous and jointless from manhole to manhole and, for laterals (see Section 4.12), from the property boundary inspection point to the main or the top of the vertical dropper. Locks that connect profile strips in spiral wound liners are not considered to be joints for the purposes of this Specification clause.

4.3.2 Serviceability

The physical properties and characteristics of the finished liner are to meet or exceed the minimum properties detailed in the Product Work Statement.

The rehabilitation system is to be chemically and biologically resistant to internal exposure to sewage, sewage related gases, and mild concentrations of industrial effluent, for the service life of the lining. Chemical resistance shall include satisfactory performance in the presence of concentrations of carbon monoxide, carbon dioxide, methane, hydrogen sulphide, traces of mercaptans, gasoline, vegetable oil, petrol, kerosene, tap water (pH 5.5 - 9), saturation with moisture, detergent, soap, and dilute concentrations of sulphuric, nitric and phosphoric acid. Test procedures for determining the chemical-resistance properties of the liner and minimum chemical-resistance standards are defined in Section X2 of ASTM F1216-09.

The rehabilitation system is not to be subject to shrinkage, thermal contraction, recovery or reversion, or loss of sealing at end terminations which may adversely affect the water tightness, strength or hydraulic performance of the lining following installation.

The material properties of the rehabilitation system are to remain stable within a range of temperatures from -10°C to +40°C.

If the pipeline transports trade waste and/or waste at temperatures outside this range, it will be stated in Section 4 of the project-specific Specification. Select a lining system that is suitable for the conditions likely to occur.

The lining is to be resistant to external exposure to soil bacteria and any chemical attack that may be due to residues remaining on the pipe wall or materials in the surrounding ground.

The rehabilitation system is to be resistant to abrasion from the migration of silt, sand and debris along the pipe.

The rehabilitation system is to be sufficiently robust to withstand a minimum of twelve (12) pipeline cleaning operations a year using water jetting nozzles operating at up to 170 Bar, as may be required to remove blockages or debris accumulation in the pipeline.

4.3.3 Physical Properties & Characteristics of Finished Liner

The thickness and physical properties of the installed liner are to meet or exceed those used in the structural design of the liner provided with the Product Work Statement.

Unless stated otherwise in Section 4 of the project-specific Specification, installation of the liner into a main is not to reduce the internal diameter of the pipe by more than 10%. This permitted reduction is in addition to the reduction allowed for minor protrusions and deformations – refer to Section 4.6.3. For laterals, installation of the liner into a lateral is not to reduce the internal diameter of the pipe by more than 15%. This permitted reduction is inclusive of wrinkles, protrusions and deformations. In addition, following installation of the liner there must be no significant obstruction to flow through the pipe or any obstruction to the passage of cleaning or inspection equipment. This is particularly important for the lining of laterals.

The finished liner is to comply with the requirements outlined in Section 4.7.4.

4.4 Design

4.4.1 General

Designers are responsible for:

- Determining the extent of rehabilitation required
- Determining if the site specific design parameters differ from the standard parameters outlined in Sections 4.4.3 and 4.4.4 below
- Determining the types of rehabilitation that are suitable/not suitable, with reference to Designers' Guideline 051, 'Guidance Notes for Pipe Lining Specification'
- Undertake an hydraulic check of the pipe network to determine if lining is feasible with regards to hydraulic capacity of the pipes proposed to be lined
- Undertake a desktop study to determine live and dead laterals, including identification of laterals where Delivery Team is to undertake dye testing
- Scheduling the required works to enable the Target Out-turn Cost to be prepared
- Highlighting any risks that could affect cost or the satisfactory completion of the works

The Delivery Team is responsible for:

- Selection of the Specialist Lining Contractor

- Selection of the particular rehabilitation technique to be used, considering the guidance given by the Designers
- Undertaking dye testing to determine status of laterals which could not be conclusively identified as live or dead by Designers
- Confirming the pipe and laterals are suitable for lining, i.e. that the host pipe can be prepared in accordance with Section 4.6 and the installed liner will meet the standard of finish requirements of Section 4.7.4.
- Design of the liner
- Determining the extent of works required to prepare the pipe prior to lining, and undertaking these works
- Determining the installation methodology and installing the liner
- Quality assurance
- Preparation of as-built drawings

4.4.2 Structural Design

It is expected that the Specialist Lining Contractor will design the liner.

Where the design is not covered by the pre-approval process, prepare design calculations in accordance with Section 4.4.4 where three design cases are given. Design Cases 1 and 2 assume a fully deteriorated host pipe. Design Case 2 is applicable where the ground around the liner is subject to liquefaction. For the fully deteriorated condition, the liner is designed as a flexible pipe capable of supporting all imposed loads in its own right. Design Case 3 is for a partially deteriorated host pipe condition and is only to be used for pipes larger than DN375.

For pipes DN375 and smaller, consider Design Case 1 and if the ground is subject to liquefaction, then also consider Design Case 2 and select the liner than satisfies the more conservative of the two design cases.

For pipes larger than DN375, the design cases that are to be considered are specified in Section 4 of the project-specific Specification. Design the liner for each of the specified design cases. Select the liner that satisfies the more conservative of the design cases.

The design is to assume that there is no bond between the liner and the existing pipe.

If the ground around the liner is subject to liquefaction, it will be stated in Section 4 of the project-specific Specification. In which case then, also design the liner to withstand the fully deteriorated gravity pipe condition with the additional parameters defined in Section 4.4.4.

Designs are to be in accordance with the relevant ASTM Standards.

The parameters that are to be used in the design are defined Sections 4.4.3 and 4.4.4 below.

4.4.3 Design Input Parameters – Material Properties

The material properties used in the design are to be consistent with the composition of the lining material utilised in the rehabilitation. Test certificates issued by IANZ-accredited laboratories or recognised test laboratories for tests conducted on comparable samples taken from previous installations are to be provided to justify the material properties nominated.

Where material properties under load vary with time, use the material properties of the lining at the end of the fifty-year service life in the design calculations. The exception to this is design of the

lining for loads applied only during installation, which may be based on short-term material properties.

The two-year values for ring-bending stiffness of the lining, as determined by long-term testing, may be used as representative values for the fifty-year buried pipe stiffness.

If testing has not been carried out, assume the long-term material properties are 50% of the short-term values except for epoxy liners, where assume that the long-term material properties are 33% of the short-term values.

4.4.4 Design Input Parameters – Design Cases

Design Case 1

Design the liner for the fully deteriorated condition in accordance with the following parameters:

- Soil density – 20 kN/m^3
- Soil Modulus – 2 MPa for pipes DN375 and smaller

  – 2 MPa or 4 MPa, as specified in Section 4 of the project-specific Specification for pipes larger than DN375
- Traffic loading – In accordance with the loading charts in Appendix A, using the ‘CCC Roads’ curves unless installation is under a State Highway in which case use the ’State Highway’ curves.
- Water table – at ground level
- Factors of Safety – at least 2
- Existing pipe ovality – 2%, unless specified otherwise in Section 4 of the project-specific Specification
- Liner properties – as specified in the relevant ASTM Standard (typically long-term properties)

Design Case 2

If the ground around the liner is subject to liquefaction, then also design the liner for the fully deteriorated condition in accordance with the following parameters and select the liner that satisfies the more conservative of the two design cases.

- Soil density – 18 kN/m^3
- Soil Modulus – 0.5 MPa
- Traffic loading – Nil
- Water table – at ground level
- Factors of Safety – at least 2
- Existing pipe ovality – 2%, unless specified otherwise in Section 4 of the project-specific Specification
- Liner properties – short term properties

Design Case 3 (for pipes larger than DN375)

Design the liner for the partially deteriorated condition in accordance with the following parameters:

- Liquefied material – liquefied layer assumed to act as a fluid extending to the ground surface with density of 18 kN/m^3
- Factors of Safety – at least 4
- Existing pipe ovality – 2%, unless specified otherwise in Section 4 of the project-specific Specification
- Liner properties – short-term properties

4.4.5 Design Calculations

Provide design calculations to demonstrate the adequacy of the liner.

For pipes DN375 and smaller it is envisaged that under the approval process calculations will be provided to demonstrate the adequacy of liners over a range of different circumstances. Following approval of a liner design, it will only be necessary to provide further design calculations for cases that fall outside the approved range.

Provide design calculations in sufficient detail to allow for the calculation to be checked and verified.

Each calculation is to be complete, showing the following details:

- Definition of terms used in the calculation
- All input data values
- References to test results to justify material properties
- All units of measurement and conversion factors, where applicable
- Calculation formulae, with references to the equation numbers or relevant clauses given in the standard
- Details of any proposed deviation from the design standard

4.5 Overview of Lining Process

4.5.1 General

Personnel are not to enter the pipe at any stage either before, after or during the lining process.

Select the rehabilitation system to be installed and, with the Specialist Lining Contractor, establish a methodology that will ensure that the finished liner complies with the requirements of this specification.

Measure the dimensions of the pipeline to be lined and inspect the pipeline to establish the extent of preparation works required.

If either the dimensions of the pipeline or the scope of works identified on site differ from what is shown on the drawings, or in Section 4 of the project-specific Specification, refer back to the Designer before proceeding.

4.5.2 Lining Sequence

The works are to generally be carried out in accordance with the following sequence of works:

- Clean and inspect the existing pipe
- Confirm the dimensions and condition of the pipe, and its suitability for lining

- Identify all live and dead laterals and confirm which laterals connections are to be reopened after lining
- Install and test flow management, if required
- Remove all material likely to cause protrusions in the finished line. All roots, fat and loose debris that may damage or weaken the finished liner are to be removed
- CCTV survey cleaned pipe and log location of laterals and faults if patch repair only is required
- Install patches if necessary
- Install pre-liner, if necessary, to meet site specific installation conditions
- Install liner
- Undertake air test
- Re-open live laterals
- Install lateral junction repairs on all lateral connections, unless stated otherwise in Section 4 of the project-specific Specification. This can be done either before or after the laterals are lined.
- Line laterals (if required)
- CCTV survey main pipe and laterals on completion of lining

4.6 Pre-Installation Activities

4.6.1 General

Have the Specialist Lining Contractor confirm the suitability of each pipeline section for lining, and assess the preparation works required, prior to starting preparation of the pipeline for lining.

For each liner installation where the design has been pre-approved (pipes DN375 and smaller), have the Specialist Lining Contractor provide a statement that the installed liner will conform to the details provided in the pre-approval application and confirm that lining will comply with the circumstances and limitations given in the pre-approval.

4.6.2 Determination of Liner Size

Measure the dimensions of the host pipe. View the existing CCTV inspection to identify variances in diameter along the pipeline, e.g. those due to earthquake damage, corrosion and deformation. Undertake this prior to the lining material being ordered. Keep a record of the location and sizes of any variances in diameter and any protrusions and deformations.

Size the liner to the minimum and maximum dimensions of the host pipe. Make allowance, where appropriate, for longitudinal and circumferential stretching of the liner during installation, so that a neat fit is achieved in the host pipe, without an excessively long tail of liner material in the receiving manhole.

4.6.3 Cleaning & Preparation of Pipeline

Clean the pipeline immediately prior to lining. Remove all internal debris, loose material and obstructions. All roots, other than small hairline roots, are to be removed.

For main lines, remove protrusions and deformations that reduce the diameter of the host pipe by percentages in excess of the values indicated in Table 1 below. The permitted reduction in diameter is exclusive of liner thickness and the thickness of the LJR where one is installed.

Table 1 Maximum Values for Protrusions and Deformations for Main

Host pipe original diameter	Maximum reduction in diameter
≤ 500 mm	10%
500 mm and above	5%

For laterals, remove protrusions and deformations that will result in the overall reduction of diameter exceeding that permitted in Section 4.3.3.

For both mains and laterals, also remove any other protrusions or sharp edged obstructions which may obstruct the liner installation, or cause damage to the liner during or after installation.

Rectify, prior to installation, any other conditions that may prevent the proper installation of the liner or affect the quality of the finished liner, such as collapsed sections, offset joints, running infiltration etc. Note these works on the as-built drawings. The rectification might involve:

- Localised repairs to sections of the host pipe
- Installing local no-dig spot repairs (NDSRs) to stabilise defects in specific locations
- Installing a pre-liner to restrict circumferential stretching of the liner, and/or to smooth transitions at displaced joints

Complete a CCTV inspection to confirm that the pipe has been properly prepared. Retain a copy of the CCTV inspection and log sheet which should identify all protrusions and deformations.

Determine and record on the as-built drawings the location, orientation and status (live/dead) of all lateral connections.

4.6.4 Flow Management

Install flow management that is adequate to ensure that service through the system is maintained, including that the properties will not experience any backflow, whilst the pipe is being prepared and the liner is being installed. Ensure that there is enough suitable equipment to allow for breakdowns or equipment outages.

Lateral connections may be plugged only after reasonable notification has been given to the affected residents and may not remain plugged overnight. Reasonable notice is considered to be receipt of a notification letter at least three working days prior.

4.7 Installation

4.7.1 General

Wherever possible, use existing manholes as launch and reception points. Consult the Designer prior to the installation of any new manholes, or removal or modification of any existing manholes.

Carry out CCTV inspection immediately prior to installation to check if any debris or contamination has entered the pipeline or the host pipe has changed since it was last inspected. Rectify any issues before the liner is installed.

Carry out installation in accordance with the methodology and quality assurance processes defined in the approved Performance Work Statement.

Sections 4.9 to 4.11 provide specification requirements that apply to the particular types of rehabilitation systems.

4.7.2 Discharge of Cure Process Water

Do not release curing water into the stormwater system. It is to be tankered away for disposal or released into the wastewater system.

Curing water released into the wastewater system is to be below 40°C. The quantity of styrene in the discharged water is not to exceed 25 ppm.

4.7.3 Manholes and Reconnection of Existing Services

After lining, ensure that liners are flush with manhole and chamber inside walls or as flush as practically possible. Seal all end terminations at manholes and chambers with a suitable grade of epoxy mortar to prevent infiltration. The epoxy mortar material is to be compatible with the liner materials and the host pipe, and is to have a service life matching the liner. Smooth the transition between the manhole or chamber entry or exit and the liner end to minimise any level differences or other irregularities that may cause debris, silt, rags, and similar materials to accumulate.

On the day of the lining, open all live lateral connections and any others specified by the Designer. For pipes DN375 and smaller open by robotic means. For pipes of larger diameter opening laterals robotically is preferred; alternatively, laterals may be opened by digging down and opening the lateral from the outside of the pipe, carrying out the opening and reconnection of the laterals in accordance with the Product Work Statement. Do not reopen dead or blank laterals, unless specified otherwise.

The opening cut in the liner at the lateral connection is to be flush with the inner surface of the lateral pipe. The cutting tool is to leave a smooth, bevelled edge free of any protrusions which may inhibit flow or catch solid material. Do not damage the existing lateral during the reopening.

Install Lateral Junction Repairs (LJR) at opened lateral connections unless specified otherwise (refer Section 4 of the project-specific Specification).

4.7.4 Standard of Finish

The installed liner is to be a close fit against the host pipe along the whole length.

The finished liner is to be free of all defects which affect hydraulic performance or structural adequacy. This is to include defects arising from substandard materials, faulty or inaccurate manufacture, inadequate pipe preparation, faulty installation or workmanship, or inadequate curing.

4.8 Post-installation Testing, Inspections and Deliverables

4.8.1 Leak Testing

Test all main pipes DN600 and smaller for leaks before the lateral connections are reopened. The test is to be in accordance with CSS: Part 3 – Utility Drainage.

In the case of CIPP liners, this test may be substituted by a leakage test during the cooling phase of the cure process.

4.8.2 Post-lining CCTV

Undertake a post-lining CCTV inspection of all liners in mainlines and laterals (including DN100 laterals) once all works have been completed. The CCTV inspection is to be in accordance with CSS: Part 3 – Utility Drainage and the Christchurch City Council Specification: CCTV for Christchurch City Council Earthquake Recovery.

During the CCTV inspection, plug or divert base flows so that there is no flow coming from the upstream manhole. Flows from live laterals into the pipe being surveyed should result in a flow in the pipe no more than 10 mm deep so that the full circumference of the pipe is visible.

Ensure that the CCTV captures the seal of the liner at both the upstream and downstream manholes or chambers. If, and only if, the camera is not able to rotate backwards to view the downstream manhole or chamber connection, a photograph that clearly shows the sealing of the end termination is acceptable. Include in the photograph a notice that clearly shows the lined pipe asset ID and manhole ID.

4.8.3 Quality Assurance

Have the completed liner assessed by a person experienced in the quality assurance of pipe rehabilitation to confirm that the installed liner meets the requirements of this Specification. It is expected that this review will be completed within one week of the work being completed. This assessment will involve a review of the following items (as a minimum):

- Pre- and post-lining CCTV footage and log sheets
- Photographs of completed laterals at the boundary inspection points (see Section 4.12) and if taken, the end terminations at manholes or chambers (see Section 4.8.2 above)
- Inspection forms and test results
- Quality assurance check sheets
- Material data sheets for all materials used in the lining process (except in situations that comply with the details provided in the approved Performance Work Statement and satisfy the circumstances and limitations listed in the product pre-approval in the Approval for Pipeline Rehabilitation Contractors and Systems document)
- Records/notes of visual inspections
- Marked up drawings to show the as-built works
- Sampling and certificates of test results
- Details of any remedial works undertaken

4.8.4 Defects

The following are considered to be unacceptable:

- Liner installed over debris – not permitted
- Liner installed over unacceptable protrusions or deformations in the host pipe – see Section 4.6.3 for maximum permitted values for protrusions and deformations
- Under-strength finished liner materials – short term flexural strength or modulus is less than the respective design value declared in the Performance Work Statement
- Defective joints e.g. popped lock in spiral wound lining – none permitted

- Excessive annular gap between liner and host pipe – annular gap results in the physical properties of the installed liner not meeting those used in the structural design of the liner (diameter, ovality), or leakage, or deformation that could trap debris
- Foreign inclusions – none are permitted
- Leakage observed through the liner – not permitted
- Leak test does not comply with requirements of Section 4.8.1
- Inadequate material curing – soft spots visible in CCTV, test results indicate that short term flexural strength or modulus is less than the respective design value declared in the Performance Work Statement
- Inadequate resin impregnation – soft spots visible in CCTV, test results indicate that short term flexural strength or modulus is less than the respective design value declared in the Performance Work Statement
- Dry spots, bubbles, cracks or de-laminations – none permitted in liner material. Debonding of the internal coating on CIPP liners is acceptable, but this should be minimised
- Pinholes – none are permitted
- Poor quality cut outs – see Section 4.7.3
- Inadequate seals at manholes – see Section 4.7.3
- Liner thickness less than specified design value – see Section 4.9.4 for specific requirements for CIPP liners
- Annular grout, if required to be used, does not fill annular space
- Excessive wrinkling of the liner. The extent of wrinkling is to be kept to a minimum. Excessive wrinkling is defined as:
    - For pipes DN375 and smaller:
        - Wrinkling > 5% of the nominal diameter of pipe
        - Any wrinkling that significantly obstructs flow through the pipe or obstructs the passage of cleaning or inspection equipment
    - For pipes larger than DN375
        - Wrinkling > 20 mm

The following features may indicate the presence of defects. If present, investigate to determine if a defect is present.

- Irregularity in liner, e.g. reduction in diameter, bulge or protrusion. This could be an indication of unacceptable preparation of the host pipe, inadequate material curing or inadequate resin impregnation.
- Excessive resin loss during installation, e.g. excessive resin slugs in laterals. This could be an indication that the liner thickness is less than the specified design value.
- Excessive annular gap. This could be an indication of incorrect liner sizing, inadequate material curing or inadequate resin impregnation.

4.9 CIPP Lining

4.9.1 Codes and Standards

Carry out installation in accordance with:

ASTM D5813-04	Standard Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems
ASTM F1216-09	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
ASTM F1743-08	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)

4.9.2 Rehabilitation System Requirements

4.9.2.1 Liner Fabric

The liner material is to be capable of stretching to fit irregular pipe sections and negotiate bends. The liner tube is to be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance is to be made for circumferential stretching during inversion.

The minimum wall thickness of the installed liner is to comply with the following, as well as the minimum thickness required to meet design loading requirements:

- DN100 pipelines 3.0 mm
- DN150 pipelines 4.0 mm
- DN225 or larger pipelines 6.0 mm

4.9.2.2 Pre-liner

Install a pre-liner if there is significant infiltration into the pipeline that could wash out the liner resin before it is cured. The pre-liner is to have sufficient strength to withstand the hydrostatic and mechanical forces imposed on it prior to and during the installation of both the pre-liner and liner.

4.9.3 Monitoring During Installation

Install thermocouples at the top and bottom of each liner at the entry and receiving manholes, and at intermediate manholes, and continuously monitor them during curing and cool down. The thermocouples are to gauge the temperature of the incoming and outgoing water supply and the temperature at various points on the surface of the liner. Record temperature as part of the ITP.

Temperatures monitored during the curing period and cool down periods are to meet the requirements of the resin manufacturer as noted in the Performance Work Statement.

4.9.4 Testing and Inspections

Take and retain samples from each installation shot. Cut samples from a section of liner that has been installed through a like section of pipe, e.g. through a mould installed in an intermediate manhole. For liners in pipes larger than 300 mm diameter, plate samples for testing may be

prepared by suspending sections cut from the impregnated liner in the curing water, such that they are cured in the same manner as the liner.

Test samples from each installation. Have the samples tested by an IANZ-accredited laboratory, in accordance with F1216-09, to determine the following properties:

- Liner thickness – to comply with F1216-09 Clause 8.6
- Short term flexural strength and modulus are not to be less than the respective design value declared in the Performance Work Statement

For pipes DN375 and smaller, once 10 consecutive samples have been tested and they all fully comply with the Specification, then the testing frequency can be reduced to one sample per 10 installations, selected at random. If any test does not comply with the Specification, then test samples from all of the installations that have been completed since the installation which had the last compliant test. The testing frequency is to then revert to every sample being tested until 10 consecutive, fully compliant samples have been tested.

4.10 Spiral Lining

4.10.1 Codes and Standards

Carry out installation in accordance with:

ASTM F1697-09	Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Strip for Machine Spiral-Wound Liner Pipe Rehabilitation of Existing Sewers and Conduit
ASTM F1741-08	Standard Practice for Installation of Machine Spiral-Wound Poly (Vinyl Chloride) (PVC) Liner Pipe Rehabilitation of Existing Sewers and Conduit

4.10.2 Rehabilitation System Requirements (Pipes Larger Than DN375)

Typically, grouting of the annulus between the liner and the host pipe will not be required. If it is required then this will be specified in Section 4 of the project-specific Specification. In some cases, even though grouting has not been specified, it may be required to satisfy structural design requirements.

4.10.3 Design for Pipes Larger Than DN375

For Design Case 1, if the annulus is grouted use a soil modulus of the lesser of 4 MPa or that specified in Section 4 of the project-specific Specification. If the annulus is not grouted use a soil modulus of 2 MPa.

For Design Case 3, if the annulus is grouted use an enhancement factor ‘K’ value of 7. If the annulus is not grouted use a ‘K’ value of 4.

4.10.4 Installation

4.10.4.1 Liner Installation

The liner is to fit neatly inside the host pipe, with the liner generally being in contact with the host pipe. The internal diameter of the finished liner is to exceed the minimum diameter specified in Section 4.3.3.

4.10.4.2 End Terminations at Manholes and Chambers

Seal the annulus between the line and the host pipe at manholes and chambers by application of epoxy prior to expansion of the liner (see Section 4.7.3). For pipes DN375 and smaller the length of annulus sealed with epoxy is to be a minimum of 200 mm. For larger pipes the length of annulus sealed with epoxy is to be a minimum of 500 mm.

4.10.4.3 Grouting for Pipes Larger than DN375

Undertake grouting annulus between the liner and the host pipe, where required, in accordance with F1741 – 08. The application methodology is to ensure that the grout fills the annular space around the liner.

4.10.5 Testing and Inspections

Retain a sample of the profile from each liner section and record the batch number of the profile.

If grouting is undertaken (on pipes larger than DN375), sample and test the grout in accordance with F1741–08.

4.11 Folded PVC Pipe (For Pipes DN375 and Smaller Only)

4.11.1 Codes and Standards

Carry out design and installation in accordance with:

ASTM F1504-10	Standard Specification for Folded Poly(Vinyl Chloride)(PVC) Pipe for Existing Sewer and Conduit Rehabilitation
ASTM F1947-10	Standard Practice for Installation of Folded Poly (Vinyl Chloride) (PVC) Pipe into Existing Sewers and Conduit

4.11.2 Materials

The materials compromising the folded PVC lining system are to comply with ASTM F1504-10.

4.11.3 Liner Installation

Seal or otherwise control running/gushing infiltration. Undertake measures so that water is not running in through laterals during installation.

The cool down process is to take account of the ambient temperature and ensure that the liner is not excessively stressed, particularly on cold days.

The liner is to fit neatly inside the host pipe, with the liner being in contact with the host pipe.

After the liner has been inserted into the host pipe, relieve any stress imparted to the liner during the insertion in a manner proscribed in the manufacturer's installation instructions.

After the formed pipe has cooled down, trim the terminating ends to a minimum of 75 mm beyond the existing pipe as an allowance for possible shrinkage during cooling to ground temperature. Once all shrinkage has taken place, the ends of the liner are to be trimmed flush with the manhole walls and the ends sealed with epoxy mortar to prevent infiltration.

4.11.4 Testing and Inspections

Prepare a rounded pipe sample from each liner section in accordance with Section 7.3 of ASTM F1947-10. Retain the sample and record the batch number of the liner.

Test at least one sample per 10 installations, in accordance with Section 7.3 of ASTM F1947-10. If a test does not comply with the Specification, then test samples from all of the installations completed since the installation which had the last compliant test result.

4.12 Lateral Lining

The decision to line a lateral or not is made at the end of a lateral inspection process that is not covered in this Specification. This section, Section 4.12, applies when it has been determined that a lateral is to be lined.

Lateral liners are to be continuous and jointless from the property boundary inspection point to the main or the top of a vertical dropper. Vertical droppers are not to be lined. Where no boundary inspection point is found within 1 m inside of the private property boundary, install a new inspection point at approximately 600 mm, but not greater than 1 m, inside the private property boundary.

Where there is a vertical dropper to the main, check that the vertical section of lateral has not dropped into the main, that CCTV inspection shows that the vertical section appears to be in good order and that the connection at the top of the vertical section is not broken. If these conditions are not met, replace the vertical dropper.

Line laterals with CIPP lining in accordance with this Specification with the following additional requirements:

- The rehabilitation system is to use a resin that has low susceptibility to shrinkage and provides a bond between the liner and the host pipe, demonstrated by the fact that there is to be no visible annulus gap between the liner and host pipe. Polyester resins are not suitable as they will not satisfy these requirements.
- The fabric used for the lateral liner is to be flexible enough to mould to the host pipe, such that the liner can be installed through tight radius bends and lateral, providing a smooth finish, with minimal wrinkling or thinning of the liner.
- The fabric tube is to be flexible, without wrinkling.
- The installation method utilised is to enable the liner to be installed as a “blind shot” with access from one end only.
- The lateral liner is to overlap the lateral junction repair, if one is to be installed, by at least 100 mm, except where a vertical dropper is not lined.
- If there is no LJR installed, the downstream end of the installed liner is to be within 100 mm of the connection with the mainline. If the liner extends into the mainline then it is to be trimmed back flush. Where the liner terminates at a vertical dropper, the liner is to terminate at least 100 mm past the connection joint.
- Take and retains samples from each installation. Test samples in accordance with Section 4.9.4.
- Test 1 out of every 5 samples. When 10 consecutive, fully compliant tests have been completed, then the testing frequency can be reduced to 1 test out of every 50 samples.
- If any test does not comply with the Specification, then test the samples from the last 10 installations, continuing until there are at least 10 consecutive, compliant tests. The testing frequency is to then revert to 1 out of every 5 samples being tested until 10 consecutive, fully compliant samples have been tested.

On completion of the lining of a lateral, take photographs of the completed lining at the property boundary inspection point prior to backfilling.

4.13 Laterals Junction Repairs

Achieve sealing of lateral connections by installing a short-form cured-in-place liner. Use the following process:

- Insert a resin impregnated junction liner within the existing pipeline to the junction position with the lateral.
- Force the resin impregnated junction liner against the host pipe.
- Cure the resin impregnated liner in place, thereby joining the cured liner to the existing adjacent lateral pipeline, and sealing the installed liner at lateral openings.

Lateral Junction Repairs (LJR) are to be comprised of either:

- A short tee that bonds to the full circumference of the main pipe liner or host pipe, and the lateral pipe; or
- A 'Top Hat', consisting of a tube that seals to the lateral pipeline and a 'brim' that seals to the liner or host pipe around the lateral opening

The LJR is to extend up the lateral pipe to at least 50 mm past the first joint. If the lateral is to be lined, then the lateral lining is to overlap the LJR by 100 mm.

The LJR is to be made of a resin that has low susceptibility to shrinkage and provides a bond between the LJR and the host pipe or liner, demonstrated by the fact that there is to be no visible annulus gap around the installed LJR. Polyester resins are not suitable as they will not satisfy these requirements.

The fabric used for the LJR is to be flexible enough to mould to the host pipe and lateral, providing a smooth finish, with minimal wrinkles.

4.14 Patch Repairs

Form patches from sections of CIPP lining in accordance with this Specification with the following additional requirements:

- Patches are to have a minimum length of 1200 mm and are to extend a minimum of 400 mm either side of the fault being repaired
- Patches are to be made using a resin that has low susceptibility to shrinkage and provides a bond between the patch and either the host pipe or liner that the patch is installed within, demonstrated be the fact that there is to be no visible annulus gap around the installed patch. Polyester resins are not suitable as they will not satisfy these requirements.
- If glass reinforcement is used in the patch, then the glass is to be resistant to exposure to sewage, sewage related gases, and mild concentrations of industrial effluent, for the service life of the lining.

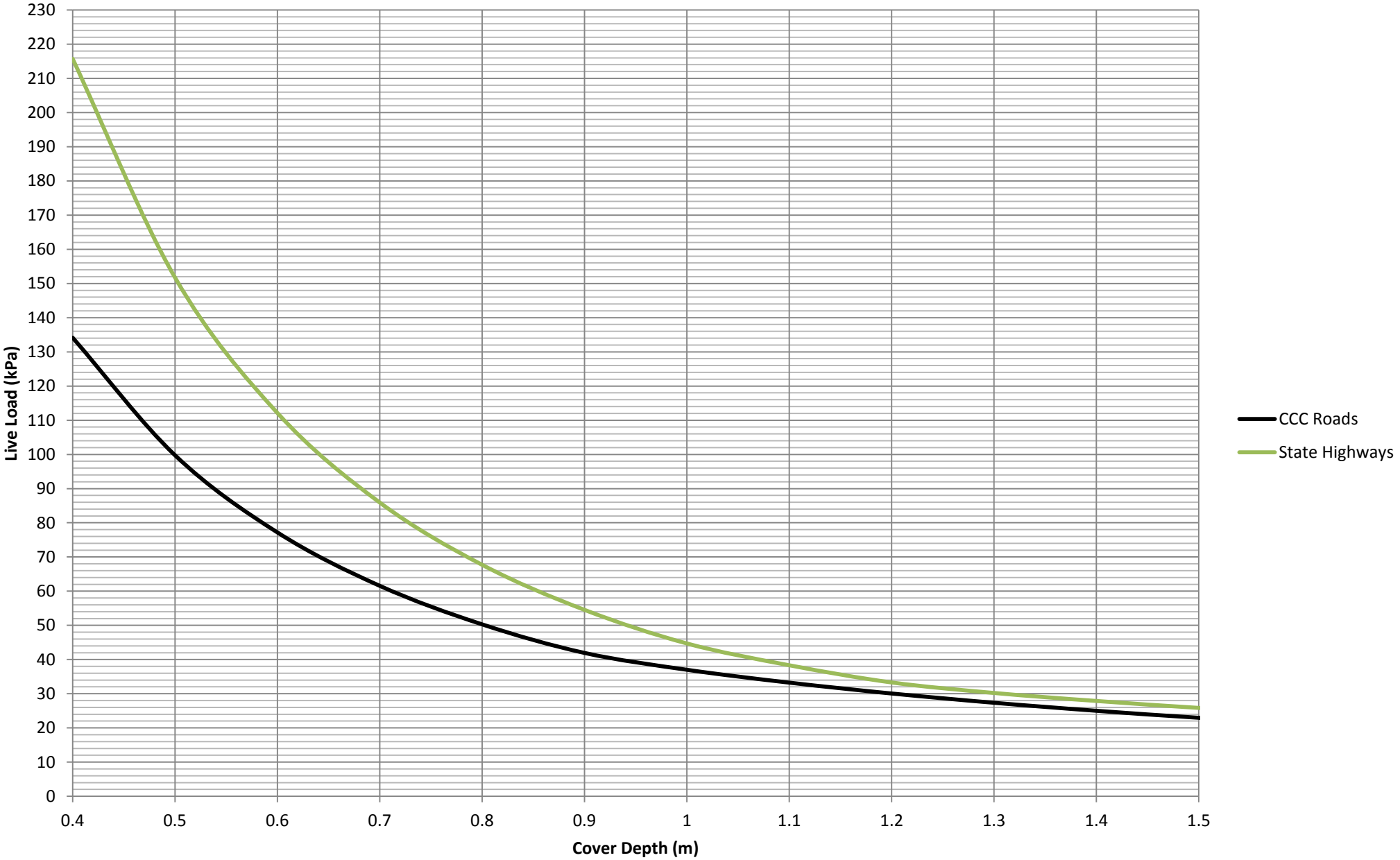
For patches Section 4.9.4 Testing and Inspections does not apply.

A

Appendix A Traffic Loading Charts

These charts are based on HN-HO-72 loading as defined in the NZTA Bridge Manual and use the load distribution and impact factor defined in AS/NZS 2566.1 and AS/NZS 3725 for the 'CCC Roads' curves and the load distribution and impact factor defined in the Bridge Manual for the 'State Highway' curves. The derived loads include the distributed UDL, the HN load factor of 1.35 (ref. NZTA Bridge Manual 3rd Edition 2013 Clause 3.2.1), consideration of single and dual lanes, and a reduction in HO loading to compensate for greater allowable stresses in the HO case as agreed between SCIRT and NZTA.

Average Intensity of Design Live Load - Road Vehicles
(Cover Depth 0.4 m - 1.5 m)



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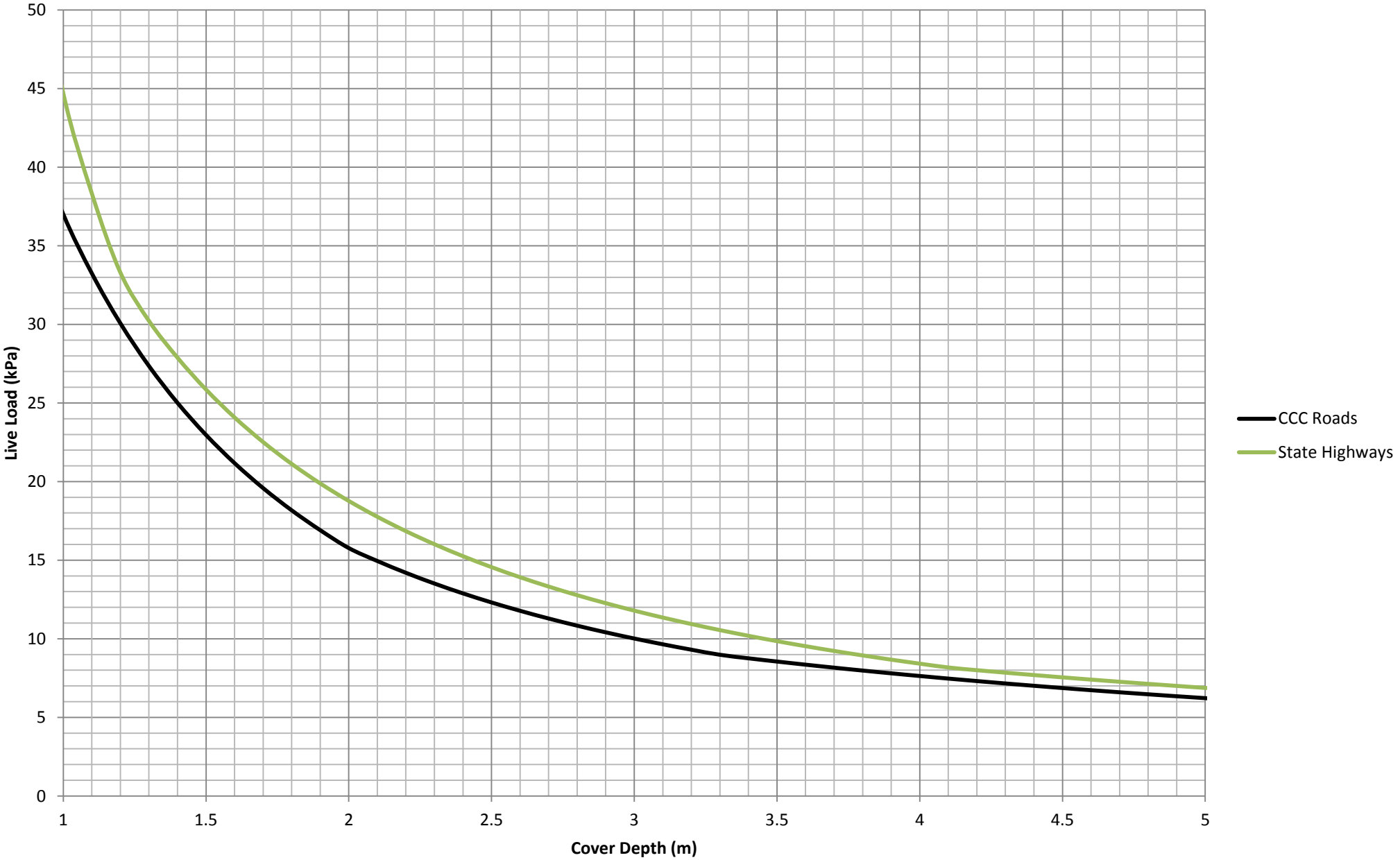
Average Intensity of Design Live Load - Road Vehicles
(Cover Depth 1.0 m - 5.0 m)



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