The Timber Bridge Manual is a reference document only. Some of the contents are out-of-date.

It is recommended to seek advice from RMS Bridge and Structural Engineering (Rehabilitation Design) prior to use.

SECTION FIVE

STRESS LAMINATED TIMBER SYSTEMS
TABLE OF CONTENTS

SECTION FIVE

5. STRESS LAMINATED TIMBER SYSTEMS 1

5.1 GENERAL 1
  5.1.1 Scope 1
  5.1.2 Objectives 1
  5.1.3 Definitions 1

5.2 STRUCTURE TYPES AND COMPONENTS 4
  5.2.1 SLT Decks 5
  5.2.2 Built-up Sections 7
  5.2.3 SLT Applications 8
  5.2.4 Components and Materials 9
    5.2.4.1 Timber Deck Components 10
    5.2.4.2 Deck Protection Systems 10
    5.2.4.3 Prestressing Materials and Anchorage Systems 10
    5.2.4.4 Deck Attachments and Accessories 11

5.3 INSPECTION PROCEDURES 11
  5.3.1 Objectives and General Requirements 11
  5.3.2 Inspection Records 11
  5.3.3 Annual Visual Inspection 12
    5.3.3.1 Inspection Under Transient Loading 12
    5.3.3.2 Wearing Surface and Drainage 12
    5.3.3.3 Timber Deck 13
    5.3.3.4 Prestressing System 15
      5.3.3.4.1 Prestressing Tendons and Anchorages 15
      5.3.3.4.2 Prestressing Bearing Plates and Channels 16
    5.3.3.5 Deck Tie Downs and Joint Assemblies 16
    5.3.3.6 Summary of Inspection Procedures 17
  5.3.4 Detailed Inspection 18
    5.3.4.1 Timber Boring 18

5.4 PREVENTATIVE AND ROUTINE MAINTENANCE 19
  5.4.1 Objectives and General Requirements 19
  5.4.2 Preventative Maintenance 19
  5.4.3 Annual Maintenance 19
    5.4.3.1 Wearing Surface, Drainage and Deck Protection 19
    5.4.3.2 Wearing Surface and Deck Protection (Waterproofing) 19
    5.4.3.3 Deck Drainage 20
    5.4.3.4 Prestressing System 20
    5.4.3.5 Monitoring of Prestress Levels 20
      5.4.3.5.1 Load Cells 21
5.4.3.6 Lift Off Readings 21
5.4.3.7 Minimum Prestress Levels and Restressing 23
5.4.3.8 Records of Prestress Levels 23
5.4.3.9 Prestressing Anchorage Protection 23
5.4.4 Deck Tie Down and Deck Joints 24
5.4.5 Summary of Annual Maintenance Procedures 24
5.4.6 Three Year and Infrequent Maintenance 24
5.4.6.1 Prestressing Systems 24
5.4.6.2 Restressing of Tendons 25
5.4.6.3 Records of Restressing 25
5.4.6.4 Prestressing Anchorage Protection 25
5.4.6.5 Deck Tie Downs and Deck Joints 26

5.5 REHABILITATION AND REPAIRS 26
5.5.1 Wearing Surfaces and Protection Systems 27
5.5.1.1 Rubberised Asphaltic Concrete 27
5.5.1.2 Rubberised Flush Seals 27
5.5.1.3 Conventional Wearing Surface with Waterproof Membrane 27
5.5.2 Timber Decking 28
5.5.3 Prestressing System 28
5.5.3.1 Replacement Single Prestressing Tendons (Under Traffic) 28
5.5.3.2 Replacement and Release of Multiple Tendons 29
5.5.3.3 Prestressing Equipment 29
5.5.3.4 Grease Protection (Prestressing Bars) 30
5.5.3.5 Prestressing Strand Protection 31
5.5.3.6 Prestressing Anchorage Plates and Bulkheads 31
5.5.4 Deck Tie Downs 31
5.5.5 Deck Joint Assemblies 32

5.6 ENGINEERING DESIGN AND EVALUATION 32
5.6.1 RTA Design Guide for SLT Decks 33
5.6.2 Design Loadings 33
5.6.3 Design Features 34
5.6.3.1 Timber Selection and Availability 34
5.6.3.2 Prestress Tendons and Restressing 34
5.6.3.3 Prestress Anchorage and Distribution Systems 35
5.6.4 Composite SLT Bridges 35
5.6.5 Green Hardwood SLT Decks 35

5.7 DETAILING AND DURABILITY 36
5.7.1 General 36
5.7.2 Wearing Surface and Deck Protection 36
5.7.2.1 Wearing Surface and Waterproofing 36
5.7.2.2 Edge Flashing 37
5.7.2.3 Deck End Flashing 38
5.7.3 Timber Deck 38
5.7.3.1 Available Timber Sizes 38
5.7.3.2 Butt Joint Frequency Laminate Layouts 39
5.7.3.3 Prestress Hole Spacing 40
5.7.4 Prestressing System 41
  5.7.4.1 Prestressing Tendons 41
  5.7.4.2 Prestress Bearing Plates and Bulkheads 41
  5.7.4.3 Prestressing Protection Systems 42
5.7.5 Deck Tie Downs 43
  5.7.5.1 General Requirements 44
  5.7.5.2 Tolerance for Installation 44
  5.7.5.3 Allowance for Future Movements 44
  5.7.5.4 Top Tie down Washer Plates 45
  5.7.5.5 Simple Plate and Washer Tie Down 45
  5.7.5.6 Steel Clip Plates on Steel Beams 46
  5.7.5.7 Angle Bracket Tie Down 46
5.7.6 Deck Joints 49
5.7.7 Deck Drainage 51

5.8 SPECIFICATIONS 53

5.9 MATERIAL SUPPLY 54
  5.9.1 Materials 54
    5.9.1.1 Timber Supply - General 54
    5.9.1.2 Prestressing Materials 54

5.10 REFERENCES 54
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 5.2-1</td>
<td>Section through SLT Deck</td>
<td>5</td>
</tr>
<tr>
<td>Figure 5.2.1-1</td>
<td>Molong Bridge: SLT (Hardwood) Deck</td>
<td>5</td>
</tr>
<tr>
<td>Figure 5.2.1-2</td>
<td>Lignum Creek; SLT Slab on Beams and Girders</td>
<td>6</td>
</tr>
<tr>
<td>Figure 5.2.1-3</td>
<td>Abbotsford Bridge, Transverse Laminated Deck</td>
<td>6</td>
</tr>
<tr>
<td>Figure 5.2.2-1</td>
<td>SLT “T” Beam and Cellular Designs</td>
<td>7</td>
</tr>
<tr>
<td>Figure 5.2.2-2</td>
<td>Korns Crossing Bridge, Cellular Design</td>
<td>7</td>
</tr>
<tr>
<td>Figure 5.2.2-3</td>
<td>Yarramundi Lagoon, Longitudinal Laminated Hardwood Deck</td>
<td>8</td>
</tr>
<tr>
<td>Figure 5.2.2-4</td>
<td>Coopernook (Bascule) Bridge, Longitudinal Laminated Hardwood Deck</td>
<td>8</td>
</tr>
<tr>
<td>Figure 5.2.2-5</td>
<td>McGraths Hill Bridge, Longitudinal Laminated LVL (Softwood) Deck</td>
<td>8</td>
</tr>
<tr>
<td>Figure 5.2.2-6</td>
<td>Pound Crossing Bridge, Longitudinal Laminated Cellular Deck. Hardwood Deck and LVL Softwood Webs</td>
<td>9</td>
</tr>
<tr>
<td>Figure 5.2.4.3-1</td>
<td>Steel Plate Anchorage on a Hardwood Deck - Molong Bridge</td>
<td>10</td>
</tr>
<tr>
<td>Figure 5.2.4.3-2</td>
<td>Protective Cap on Prestressing Strand Anchorage Grafton Bridge</td>
<td>11</td>
</tr>
<tr>
<td>Figure 5.3.3.2-1</td>
<td>Coopernook Bridge, Reflective Holes at Butt Joints</td>
<td>12</td>
</tr>
<tr>
<td>Figure 5.3.3.2-2</td>
<td>St Albans Bridge, Reflective Cracking in Surface</td>
<td>13</td>
</tr>
<tr>
<td>Figure 5.3.3.3-1</td>
<td>Uneven Laminate Surface - Hay Shire Council Bridges</td>
<td>14</td>
</tr>
<tr>
<td>Figure 5.3.3.3-2</td>
<td>Abbotsford Bridge, Hydraulic Tensioning of Tie Downs</td>
<td>15</td>
</tr>
<tr>
<td>Figure 5.3.3.5-1</td>
<td>Coopernook Bridge, Reflective Holes at Butt Joints</td>
<td>17</td>
</tr>
<tr>
<td>Figure 5.4.3.2-1</td>
<td>Waterproofing Membrane and Deck Edge Flashing</td>
<td>20</td>
</tr>
<tr>
<td>Figure 5.4.3.5.1-1</td>
<td>McCarrs Creek Bridge, Electronic Load Cell</td>
<td>21</td>
</tr>
<tr>
<td>Figure 5.4.3.6-1</td>
<td>Hydraulic Equipment for Lift Offs and Restressing</td>
<td>22</td>
</tr>
<tr>
<td>Figure 5.5.3.4-1</td>
<td>Grease Injection Tube - Pound Crossing Bridge</td>
<td>30</td>
</tr>
<tr>
<td>Figure 5.6.3.3-1</td>
<td>Prestressing Anchorage Plate and Channel- Wakool River Bridge</td>
<td>35</td>
</tr>
<tr>
<td>Figure 5.7.2.1-1</td>
<td>Wolfin Membrane - Pound Crossing Bridge</td>
<td>37</td>
</tr>
<tr>
<td>Figure 5.7.2.2-1</td>
<td>Lansdowne River Bridge, Continuous Steel Channel Anchorage System on a Softwood Deck with Wolfin Flashing</td>
<td>37</td>
</tr>
<tr>
<td>Figure 5.7.2.2-2</td>
<td>Typical Flashing Detail</td>
<td>38</td>
</tr>
<tr>
<td>Figure 5.7.3.2-1</td>
<td>Plan View of Butt Joint Requirements</td>
<td>39</td>
</tr>
<tr>
<td>Figure 5.7.3.2-2</td>
<td>Plan of Typical Laminate Layouts</td>
<td>40</td>
</tr>
<tr>
<td>Figure 5.7.4.2-1</td>
<td>Molong Bridge, Steel Plate Anchorage on a Hardwood Deck</td>
<td>42</td>
</tr>
<tr>
<td>Figure 5.7.4.2-2</td>
<td>Grafton Bridge, Protective Cap on Prestressing Strand Anchorage</td>
<td>42</td>
</tr>
<tr>
<td>Figure 5.7.4.3-1</td>
<td>McCarrs Creek Bridge, Denso Tape Protection on Prestressing Bar Anchorage</td>
<td>43</td>
</tr>
<tr>
<td>Figure 5.7.4.3-2</td>
<td>Abbotsford Bridge, Anchorage Restraint Strap</td>
<td>43</td>
</tr>
<tr>
<td>Figure 5.7.5.3-1</td>
<td>Rigid Tie Down Connection</td>
<td>45</td>
</tr>
<tr>
<td>Figure 5.7.5.4-1</td>
<td>Top Tie Down Plates - St Albans Bridge</td>
<td>45</td>
</tr>
<tr>
<td>Figure 5.7.5.5-1</td>
<td>Plate and Washer Tie Down - Grafton Bridge</td>
<td>46</td>
</tr>
<tr>
<td>Figure 5.7.5.6-1</td>
<td>Steel Clip Plate on Steel Flange</td>
<td>46</td>
</tr>
<tr>
<td>Figure 5.7.5.7-1</td>
<td>Angle Bracket Tie Down on Timber Beam</td>
<td>47</td>
</tr>
<tr>
<td>Figure 5.7.5.7-2</td>
<td>Angle Bracket Tie Down on Steel SHS Beams</td>
<td>48</td>
</tr>
<tr>
<td>Figure 5.7.5.7-3</td>
<td>Angle Bracket Tie Down _ St Albans Bridge</td>
<td>48</td>
</tr>
<tr>
<td>Figure 5.7.5.7-4</td>
<td>Angle Bracket Tie Down - Korns Crossing Bridge</td>
<td>49</td>
</tr>
<tr>
<td>Figure 5.7.6-1</td>
<td>Coopernook Bridge, Open Deck Joint</td>
<td>49</td>
</tr>
<tr>
<td>Figure 5.7.6-2</td>
<td>Pound Crossing, Compression Seal Deck Joint</td>
<td>50</td>
</tr>
<tr>
<td>Figure 5.7.6-3</td>
<td>Typical Deck Joint Detail</td>
<td>51</td>
</tr>
<tr>
<td>Figure 5.7.7-1</td>
<td>Lignum Creek Bridge, Deck Surface</td>
<td>51</td>
</tr>
<tr>
<td>Figure 5.7.7-2</td>
<td>Abbotsford Bridge, Sealed Timber Kerbs</td>
<td>52</td>
</tr>
<tr>
<td>Figure 5.7.7-3</td>
<td>Abbotsford Bridge, Deck Pipe Drain</td>
<td>52</td>
</tr>
<tr>
<td>Figure 5.7.7-4</td>
<td>Typical Detail of Deck Through Drain</td>
<td>53</td>
</tr>
</tbody>
</table>
5. STRESS LAMINATED TIMBER SYSTEMS

5.1 GENERAL

5.1.1 Scope

Section 5 covers the design, construction and maintenance of all stress laminated timber (SLT) bridge systems and specified components as outlined in Subsection 5.2.

This section is to be read in conjunction with Section 1- General and other sections as may be specified. Section 1 provides the basic requirements and procedures for timber bridges and their components. This section provides specific additional requirements relating to the SLT bridge systems.

5.1.2 Objectives

The objectives of this section are to outline the requirements of, and to provide guidance in relation to, the maintenance of SLT bridge systems with specific emphasis on:

- inspection procedures
- preventative and routine maintenance
- rehabilitation and repairs
- engineering design and evaluation
- detailing and durability
- specifications
- material supply

5.1.3 Definitions

Section 1 contains an extensive list of definitions pertaining to common terminologies, phrases and components related to timber bridges. This subsection provides additional definitions related specifically to SLT bridges.

Adaptors
Special steel fittings provided by a prestressing equipment manufacturer which allow extension bars to be attached to a tendon for jacking

Anchorage Plate
A steel plate to which the tendon anchorage is directly attached
Anchorages
A general term referring to the assembly of steel components used to attach prestressing tendons and distribute the prestressing forces to the timber

Bearing Plate
A heavy steel plate used to distribute prestressing forces to the timber (may also be an anchorage plate)

Build In Place
A term referring to the construction (assembly and stressing) of a SLT deck directly on the bridge support members (usually in its final position on the bridge)

Built-up Sections
A term referring to a SLT system composed of different components assembled to form a composite system (see Figure 5.2.2-1)

Butt Joints
The joint or discontinuity where two laminates are butted at their ends (see Figure 5.7.3.2-1)

Deck Joint
The joint at the ends of a SLT deck where it meets the adjacent span or the abutment (or approach)

Design Jacking Force
The maximum allowable jacking force on a tendon determined in accordance with the RTA Design Guide

Destress
To unload or release a prestressing tendon

Flashing
A term referring to waterproof protection provided over a component using a membrane or sheeting to protect against moisture

Grease Protection
A term referring to the injection of grease into the voids in the timber deck around the prestressing tendon (see Subsection 5.7.4.3)

Laminate Slip
A term referring to the relative vertical movement (or slip) of laminates in a SLT deck

Laminates
A general term for the timber plank components used to form a SLT deck
**Lift off**
A method of determining the residual force in a prestressing tendon using a hydraulic jack (see Subsection 5.4.3.6)

**Load Cell**
A special electronic steel device designed to fit at the anchorage of a prestressing tendon to measure the force in the tendon (see Figure 5.4.3.5.1-1)

**Longitudinally Laminated**
A SLT deck with the laminates oriented essentially parallel to the roadway

**LVL**
A manufactured timber material known as Laminated Veneer Lumber which is similar to plywood (except that the veneers are mostly in the longitudinal direction along the member)

**Prefabrication**
A term referring to the construction (assembly and stressing) of a SLT deck away from the bridge which is subsequently installed by crane or launching

**Prestress Levels**
The force in the prestressing tendons (sometimes also used to refer to the prestress pressure on the timber)

**Prestress Losses**
A term referring to the loss in prestress force in the tendons (sometimes also used to refer to the loss in prestress pressure on the timber)

**Prestressing Bar**
A prestressing tendon comprising a solid bar

**Prestressing Bearings**
A general term referring to the steel prestressing component which bears directly on the timber deck

**Prestressing Hole**
The predrilled holes in the timber laminates provided to accommodate the prestressing tendons

**Prestressing Strands**
Prestressing tendon made of (7-wire) high strength wire

**Prestressing Tendons**
A general term referring to either a prestressing bar or strand
Restressing
The re-tensioning of a prestressing tendon

SLT
Abbreviation for stress laminated timber

Tendon Forces
Forces in a prestressing bar or strand

Tie Downs
The attachments used to secure a SLT deck to the supporting members

Transverse Laminated
A SLT where the laminates are oriented essentially perpendicular to the roadway

Uniform Pressure
A term referring to the assumed average (uniform) pressure on the timber laminates created by the prestressing

5.2 STRUCTURE TYPES AND COMPONENTS

The stress laminated timber system is a form of timber bridge construction developed in Ontario, Canada in the 1970s [1] and first introduced into New South Wales in 1991 [2].

The SLT design uses the more readily available smaller timber cross section sizes ranging from 120 mm x 35 mm through to 290 mm x 45 mm and lengths of up to 6 m.

The basic concept, and most common form of construction, is shown in Figure 5.2-1. The timber (laminates) are oriented on edge and assembled to form a continuous slab and then stressed together using high strength prestressing strands or bars. The completed assembly remains under lateral pressure which creates friction between the laminates to form a strong and lightweight structural slab.

While this is the most common SLT design, there are some newer developing designs which use larger manufactured timber components as outlined in Subsection 5.2.2.
5.2.1 SLT Decks

SLT decks have been constructed from both hardwood and softwood timber. They have been applied as complete superstructures (Figure 5.2.1-1) spanning between supports and as deck slabs on larger superstructures (Figure 5.2.1-2) supported on beams and girders.
Figure 5.2.1-2 Lignum Creek; SLT Slab on Beams and Girders

While the majority of SLT designs use longitudinally laminated decks (ie: laminates are oriented along the bridge), it is also feasible to have transverse laminated decks as shown in Figure 5.2.1-3.

Figure 5.2.1-3 Abbotsford Bridge, Transverse Laminated Deck

In all designs, the SLT system is detailed to allow prefabrication of all the timber elements (laminates). The laminates are kiln dried, milled to size, docked to length and predrilled (for the prestressing tendons) in accordance with specific material requirements which are outlined in Subsection 5.9. The laminate layouts are detailed to satisfy specific butt joint configurations in order to meet minimum design criteria as called for by the design specifications which are outlined in Subsection 5.6.
5.2.2 Built-up Sections

While the most common form of construction is the slab, this design has limited span capability and can only reach up to about 9 m using high grade hardwood timbers.

The SLT concept has also been developed to provide longer span built-up designs using “T” beam and cellular sections. Figure 5.2.2-1 shows the basic built-up section designs which have been used to reach spans of up to 25 m overseas and 12.5 m here in NSW [2] (see Figure 5.2.2-2).

![Figure 5.2.2-1 SLT “T” Beam and Cellular Designs](image)

These built-up sections use the same small sawn timber sections along with larger manufactured structural timber members to form the main webs. These manufactured members can be made from either glue-laminated timber or laminated veneer lumber (LVL). Currently these manufactured members use softwood timber but could also be designed to use hardwood, if available in the market. However, these manufactured components must be made to satisfy certain strength and durability requirements.

![Figure 5.2.2-2 Korns Crossing Bridge, Cellular Design](image)
5.2.3 SLT Applications

While SLT designs have been applied to new construction, their primary applications have been as deck replacements on existing bridges. These have included both timber (Figure 5.2.1-2) and steel bridges (Figure 5.2.1-3). Some additional applications are shown in Figures 5.2.2-3 to 5.2.2-6.

Figure 5.2.2-3  Yarramundi Lagoon, Longitudinal Laminated Hardwood Deck

Figure 5.2.2-4  Coopernook (Bascule) Bridge, Longitudinal Laminated Hardwood Deck
Figure 5.2.2-5   McGraths Hill Bridge, Longitudinal Laminated LVL (Softwood) Deck

Figure 5.2.2-6   Pound Crossing Bridge, Longitudinal Laminated Cellular Deck. Hardwood Decking and LVL Softwood Webs

In addition to the basic design options, the SLT system can also be designed to suit a number of alternate construction methodologies. These include combinations ranging from a complete build-in place scenario (Figure 5.2.1-3) through to total off-site prefabrication (Figure 5.2.2-2).

5.2.4 Components and Materials

This section covers all components of stress laminated timber bridge systems and specific attachments as outlined below. Additional component details are outlined in Subsection 5.7.
5.2.4.1 Timber Deck Components
Timber deck components include all hardwood and softwood (sawn) timber laminates, laminated veneer lumber and other manufactured timber components which form part of the structural SLT deck system. Timber kerbs are also considered where they form part of the drainage and/or protection system as will be discussed in Subsection 5.7.

5.2.4.2 Deck Protection Systems
Deck protection includes the preservative treatment of softwood timbers and the sapwood in some hardwood. This preservative treatment is usually applied only after the laminates have been fully fabricated.

In addition to preservative treatment, the timber must be protected against direct moisture ingress. This protection is provided on the top, sides and ends of the SLT deck.

The top surfaces of SLT decks are protected with a waterproof membrane which can consist of either an actual physical membrane such as Wolfin or a rubberised bitumenwearing surface. The sides and ends of SLT decks are fitted with flashing to keep the exposed timber dry. This flashing can consist of galvanised metal or a rubber type material which can be placed under the anchorages. Additional details are outlined in Subsection 5.7.

5.2.4.3 Prestressing Materials and Anchorage Systems
Prestressing materials include high strength strands and bars as well as the steel components of the anchorage and bearing system, along with any specific protection devices used on the prestressing system.

Prestressing anchorage systems can vary from the typical steel plate system shown in Figure 5.2.4.3-1 to more complex systems using steel channels as shown in Figure 5.2.4.3-2.

![Steel Plate Anchorage on a Hardwood Deck – Molong Bridge](image)
Section Five Page 11 of 55

Figure 5.2.4.3-2  Protective Cap on Prestressing Strand Anchorage
Grafton Bridge

Additional details of the prestressing system are outlined in Subsection 5.7.

5.2.4.4 Deck Attachments and Accessories

There are other specific attachments and accessories which also form part of
the SLT system. These include the deck tie down components, deck joint
assemblies, drains and kerbs. Typical details are outlined in Subsection 5.7.

5.3 INSPECTION PROCEDURES

Section 1 outlines the basic inspection procedures for all timber bridge types
and these procedures also apply to stress laminated timber. This subsection
highlights specific additional considerations for SLT bridges.

5.3.1 Objectives and General Requirements

The basic objectives and requirements outlined in Section 1 must be
considered during the inspection of SLT bridges.

5.3.2 Inspection Records

• Detailed inspection records as outlined in Section 1 must be maintained for
  all inspections.

In addition, for SLT decks, it will be necessary to maintain a record of the
tendon forces as outlined in Subsection 5.3.3.4.
5.3.3 Annual Visual Inspection

Annual visual inspections should be carried out on all SLT bridges and should be done together with the annual maintenance works as outlined in Section 1.

Due to the unique nature of the SLT bridge system compared to traditional timber bridges, some additional information is outlined in the following sections.

5.3.3.1 Inspection Under Transient Loading
SLT deck systems are generally very stiff and perform as structural plates. The deck should be observed under traffic for any excessive deformations or inconsistencies in general performance (ie: localised increases in deflection). Unusual movements are usually caused by a loose or damaged tie down. However, the performance of the SLT system is also dependent on maintaining a minimum prestress pressure on the timber laminates. This is outlined in more detail in Subsection 5.4.3.7.

5.3.3.2 Wearing Surface and Drainage
The deck surface should be generally inspected for any signs of water entrapment or blocked drains. Any areas which would prevent the clear flow of rainwater off the deck should be noted.

Since SLT deck systems are generally very stiff and perform as structural plates, they can support a bitumen wearing surface. The wearing surface should be inspected for cracks or deterioration as it is unusual for the surface on these decks to be damaged through vehicular loading. Cracks in wearing surfaces can be caused by either an improper design (ie: too flexible) or, more often, loose or damaged tie downs.

The majority of new designs specify that the butt joints in the top surface of the timber deck be sealed prior to placing the waterproofing and/or wearing surface. Some existing bridges with thin flush seal wearing surfaces have shown reflective gaps in the surface at butt joints as shown in Figure 5.3.3.2-1.

![Figure 5.3.3.2-1 Coopernook Bridge, Reflective Holes at Butt Joints](image-url)
Another typical problem is reflective cracking of the surface which displays the individual laminates as shown in Figure 5.3.3.2-2. This is generally caused by a flush seal wearing surface which is too thin.

![Figure 5.3.3.2-2 St Albans Bridge, Reflective Cracking in Surface](image)

A particular problem relates to softwood decks which have been pressure preservative treated with an oil borne preservative, particularly creosote. If the timber is overtreated, or not properly conditioned after treatment, the preservative can bleed to the surface and cause the wearing surface to break down as shown in Figure 5.3.3.2-3.

![Figure 5.3.3.2-3 McCarrs Creek Bridge, Deteriorated Wearing Surface](image)

Regardless of the cause, any breaks in the wearing surface can lead to water accessing the deck and eventual timber deterioration. Some additional information and methods of repair are outlined in Subsection 5.5.

### 5.3.3.3 Timber Deck

All exposed areas of the timber deck should be visually inspected. Any structural defects, member fractures, deterioration or moisture should be
recorded. Unlike traditional timber girders, beams and planks, it is not typical for SLT deck systems to display any splitting and checking of the timber. Any signs of physical fracture or distress should be recorded and investigated. The timber around and directly under the prestressing anchorages will be addressed in Subsection 5.3.3.4.

While the laminates are carefully aligned during construction it is not uncommon for the deck surface (including the underside) to vary as shown in Figure 5.3.3.3-1. This may be caused by variations in the laminate dimensions and prestress hole locations. The primary objective during assembly is to ensure that the prestress holes are properly aligned. Hence, the surface alignment is secondary. The deck shown in Figure 5.3.3.3-1 is an extreme case and generally the relative variations between laminates should not exceed 15 mm. Laminate slip, or relative movements of laminates, can occur if the prestress pressure falls very low. However, this is very rare. If laminate slip is suspected, the deck should be monitored under heavy loads at both high and low speeds and the prestress level should be checked as outlined in Subsection 5.4.3.5.

![Uneven Laminate Surface - Hay Shire Council Bridges](image)

A careful inspection should be made under the deck, particularly under any flashing, at deck joints and deck tiebolts for any signs of moisture ingress or insect activity. The timber in SLT decks is kiln dried and its equilibrium moisture content, under long term field application, should stay well below 20%. Occasional surface wetting caused by high wind and rain should not be considered critical. However, any signs of water staining should be recorded and the cause should be investigated. Electrical moisture meters may be used (see Figure 5.3.3.3-2) to measure the moisture below the surface. Only continued and frequent wetting of the deck should raise the internal moisture content of the timber.
5.3.3.4 Prestressing System

All visible components of the prestressing system should be inspected for deterioration or signs of distress. Unless lift off are scheduled, as outlined in Subsection 5.4.3.5, it is not necessary to remove any protective devices or to have hydraulic stressing equipment on site, except as noted below.

5.3.3.4.1 Prestressing Tendons and Anchorages

The exposed bar and strand anchorages should be fully protected either by caps or denso tape as outlined in Subsection 5.7.4.3. The internal voids surrounding the prestressing tendons are pumped full of grease as part of the construction process. If water penetrates these voids it can initiate leakage of the grease at the anchorages or through minor defects in the timber. In the case where signs of leakage are observed, several anchorages should be uncovered in that vicinity.

Water ingress will change the consistency of the grease and usually cause it to turn grey. However, it is important to differentiate between water simply accessing the anchorage protection device at the ends of the tendons and water actually penetrating the void in the deck. Where water ingress is discovered, the cause must be investigated and prevented. In the extreme case, it may be necessary to destress and remove some tendons to perform a more detailed inspection. This action should only be performed under approved supervision. It should be noted that, in most cases, it is possible to determine the state of the internal grease protection during the scheduled lift off and/or restressing as outlined in Subsection 5.4.3.4.
5.3.3.4.2 Prestressing Bearing Plates and Channels

All steel prestressing components should be galvanised. Unprotected or damaged steel should be treated with zinc rich epoxy primer.

Generally, the design of the prestressing anchorage is such that they are reasonably stiff but, since the timber is relatively soft, they can still deform slightly under very high prestressing forces. The design requirements, outlined in Subsection 5.6, provide a balance between economy and aesthetics. Therefore, except in the case of continuous steel systems, such as shown in Figure 5.2.4.3-2, some local and overall deformations of the steel bearing plates and the SLT deck may be observed.

It is difficult to quantify the level of deformation that would be considered acceptable. However, the timber beneath the steel bearing plates or channels should not be visibly crushed. In addition, the edge of the deck should display a consistent deformed shape along its length. Where the prestress bearing area does exhibit deformation, some measurement of this shape should be recorded and checked again during future inspections. Increasing deformation can be caused by compressive failure of the timber which may lead to excessive losses of prestress.

5.3.3.5 Deck Tie Downs and Joint Assemblies

Typically tie downs and deck joints use high strength bolts which are tightened to specific tensions and are sometimes tensioned with hydraulic jacks as shown in Figure 5.3.3.5-1. The timber in a SLT deck is kiln dried and, therefore, there is very little shrinkage of the timber to cause loosening of bolts. However, through a variety of variables, the bolts do lose some tension during the first year and retightening after 12 months is a part of the required preventative maintenance regime, as outlined in Subsection 5.4.4. Subsequently, at least 5% but not less than 12 of the nuts/bolts of the tie down and deck joint system, should be physically tested for tightness during annual inspections.
5.3.3.6 Summary of Inspection Procedures

The following is a summarised list of the items for the routine visual inspection of SLT bridges. More detailed information is contained in the previous sections as referenced:

- the SLT deck should be inspected under traffic for any excessive deformations or movements 5.3.3.1
- particular emphasis should be given to possible slip between the laminates under heavy loads 5.3.3.3
- drainage systems should be inspected for blockages or debris 5.3.3.2
- the wearing surface should be inspected for cracks and deterioration 5.3.3.2
- the waterproofing system, including the edge flashing, should be inspected for damage and leaks 5.3.3.2
- all areas of exposed timber decking should be inspected for fractures, deterioration and signs of moisture or staining 5.3.3.3
- the timber directly under the prestressing anchorages should be inspected for excessive crushing 5.3.3.4.2
- all exposed components of the prestressing system should be visually inspected, with emphasis on:
  - damage to the anchorage protective system 5.3.3.4.1
  - excessive deformation of the anchorage system 5.3.3.4.2
- the deck tie down bolts and deck joint bolts should be

---

Figure 5.3.3.5-1  Abbotsford Bridge, Hydraulic Tensioning of Tie Downs
inspected for tightness and at least 5%, but not less than 12, of the tie down bolts should be physically checked for tightness.

5.3.4 Detailed Inspection

In addition to the annual visual inspection, a more detailed inspection must be carried out every three years and should include:

- integration of the inspection with the three year maintenance activities and extending the visual inspection to hidden areas
- exposing questionable areas with particular emphasis on:
  - inside protective caps and the coatings for prestressing anchorages (at least 10% of the tendons but not less than six are to be checked)
  - under flashing, particularly at the ends of the deck
  - under the deck at the support bearings
  - around bolts at tie downs and other fixings
  - around drains and under scuppers/kerbs
- boring of the deck should generally not be carried out unless deterioration is suspected
- it is also necessary to perform lift offs on at least 10% of the tendons (but not less than six tendons). This action is required in addition to any electronic load cell readings in order to confirm the load cell information.

As will be outlined in the subsequent sections, restressing of the deck depends on the residual force in the tendons. As the flexibility of the prestressing systems vary between bridges, so will the periods between restressing.

5.3.4.1 Timber Boring

Where boring is carried out the standard methods and identification for timber test bores, as outlined in Section 1, shall be applied except as noted below:

- boring shall be performed only if deterioration is suspected
- boring shall be performed from the underside of the deck only
- the location of the prestressing strands adjacent to any proposed bore location shall be clearly marked on the deck before drilling commences
- laminates shall be bored within 100 mm of their ends except that no holes shall be closer than 75 mm to the centre of a prestressing strand
- care shall be taken not to drill completely through the deck
5.4 PREVENTATIVE AND ROUTINE MAINTENANCE

Section 1 outlines the basic maintenance procedures for all timber bridge types which also apply to SLT decks. This subsection highlights specific additional considerations for SLT bridges.

5.4.1 Objectives and General Requirements

The primary objectives of, and general requirements for, maintenance activities are outlined in Section 1.

5.4.2 Preventative Maintenance

As outlined in Section 1, maintenance should begin with preventative measures to enhance durability through proper materials selection as well as design and construction detailing. In addition to the basic engineering and construction detailing outlined in Section 1, Subsection 5.7 reviews a number of design details specifically applicable to SLT bridges.

5.4.3 Annual Maintenance

In general, SLT bridge deck systems require very little maintenance compared to the traditional form of timber construction (which is one of its primary benefits). The SLT is a continuous structural system which should not exhibit any loosening of its components if properly maintained.

The following sections outline some of the areas which require preventative or routine maintenance specifically directed towards SLT bridges. In some cases, the types of records which should be kept are outlined along with the required equipment, where applicable.

5.4.3.1 Wearing Surface, Drainage and Deck Protection

The wearing surface, deck protection and drainage system work together to discharge rainwater and keep the timber deck dry. This is critical to durability of the timber deck.

5.4.3.2 Wearing Surface and Deck Protection (Waterproofing)

In general, the integrity of the wearing surface and waterproofing system should be maintained. Deteriorated and/or cracked areas of the wearing surface, including reflective cracks at butt joints (see Subsection 5.3.3.2), should be repaired and sealed, particularly where the waterproofing system is formed by the use of a rubberised bitumen wearing surface.
Local depressions in the wearing surface should also be filled as they can cause ponding and water can eventually work its way to the timber, regardless of the waterproofing system.

Any damage to exposed areas of waterproofing membranes and deck edge flashing, which are usually exposed along the shoulders of the deck (see Figure 5.4.3.2-1), should be patched in accordance with the manufacturer's or supplier's specifications.

**Figure 5.4.3.2-1  Waterproofing Membrane and Deck Edge Flashing**

5.4.3.3 Deck Drainage

All deck drainage areas should be cleared of debris annually including:

- shoulders of the deck surface
- deck through drains
- under scuppered kerbs
- open deck joints

In addition, the support bearings and sills below open deck joints should be cleared of accumulated debris.

5.4.3.4 Prestressing System

The prestressing system requires very little preventative maintenance except for periodic checking of the prestress levels and restressing at certain times, as will be outlined in the following sections.

5.4.3.5 Monitoring of Prestress Levels

The design of prestressing systems is continually changing and newer systems are constantly being introduced which reduce the amount of prestress losses
that occur with time. Therefore, it is difficult to provide a schedule or timing for restressing which will suit all applications.

Monitoring of prestress levels is carried out by one of two methods. Some bridges have electronic load cells installed, while others require lift off to be performed using hydraulic equipment. Prestress levels should be recorded at least once a year.

5.4.3.5.1 Load Cells

Electronic load cells, as shown in Figure 5.4.3.5.1-1, are specifically designed to monitor the tendon forces. The loads are measured using a dedicated electronic meter which is calibrated for that particular device. The bridge file record should identify the load cell type and location, as well as the availability of the meter required.

Each load cell has a receptacle into which an electronic cable is plugged and the meter provides readings directly in kilonewtons. Readings are to be recorded and forwarded to Bridge Engineering for entry into the SLT database as outlined in Subsection 5.4.3.8.

5.4.3.6 Lift Off Readings

Where no load cell is provided, the tendon forces can be measured using a method referred to as “lift off” readings. The equipment required is shown in Figure 5.4.3.6-1 (for one particular bridge) and usually includes:
• a calibrated hydraulic hollow core jack of sufficient capacity
an extension adaptor with back-up plate and anchorage
- a steel stressing chair to facilitate access to the bridge anchorage
- a hydraulic pump, hoses and fittings
- and a hydraulic pressure gauge specifically calibrated to the jack

Figure 5.4.3.6-1 Hydraulic Equipment for Lift Offs and Restressing

The lift off is simply performed by slowly increasing the load on the jack/tendon while carefully observing the permanent anchorage (nut or strand barrel) at the anchorage plate for movement. When the anchorage starts to move away from the steel anchorage plate (no more than 2 mm or 3 mm), the reading on the pressure gauge should be recorded. The process should be repeated at least twice and the two successive readings should be within 5% of each other.

It should be noted that where the overall tendon length is over 4 m (which applies to nearly all RTA bridges), the actual tendon force will not vary much when the anchorage moves away from the plate over several millimetres. However, the anchorage should not move more than 5 mm.

Certain precautions should be observed when lift off readings are being taken and these include the following:

- the equipment must be calibrated and be supplied with a recent calibration chart (as specified in RTA Form 2115)
- only approved adaptors supplied for that specific prestressing tendon should be used
- the tendon design forces and maximum jacking forces should be known and the latter should not be exceeded under any circumstances
- the position of the permanent anchorage should not be changed during this procedure (if restressing is not being performed) or it will change the final tendon force when it is released
• the work must be supervised or performed by approved personnel only

5.4.3.7 Minimum Prestress Levels and Restressing

In general, all SLT decks will require restressing some time during their life. However, the timing will depend on the level of force in the tendons. While the details of the design requirements for SLTs will be outlined in Subsection 5.6, the basic requirements which directly influence the need to restress are set out in Subsection 5.4.6.

5.4.3.8 Records of Prestress Levels

The tendon forces, measured by either load cell or lift offs, along with the final tendon levels, if restressing is carried out, should be recorded and forwarded to Bridge Engineering marked to the attention of the Maintenance Manager. This data should include the following information:

• bridge name, number and location
• date the work was performed
• tendon identification numbers for each recorded tendon force with reference to the numbering used in the SLT database
• general weather conditions and temperature
• equipment used, including identification where applicable
• name of person performing the work

5.4.3.9 Prestressing Anchorage Protection

The integrity of any exposed prestressing anchorages should also be checked on a continuing basis.

Most steel anchorage, bearing and distribution components of prestressing systems are galvanised and, therefore, will require no preventative maintenance for an extended period. However, due to the nature of the initial prestressing, periodic lift offs and restressing, the steel components can become damaged. Any areas displaying signs of rust should be repaired with an approved rust resistant paint or primer on an annual basis.

The nylon protective caps (see Figure 5.2.4.3-2) used with prestressing strands should provide a relatively long life, at least equal to the life of the prestressing tendon. However, these, and other types of caps, should be checked annually to see that they remain tight. At least 5% of the total number of caps, but not less than 12, at any one site should be checked annually. If some are found to be loose, the integrity of the anchorages inside the caps should be checked. Where any deterioration is discovered, all of the caps should be removed in turn and new grease applied to the anchorages before the caps are secured back in place.
5.4.4 Deck Tie Down and Deck Joints

All the bolts for deck tie downs and joint assemblies, as outlined in Subsection 5.3.3.5, should be retightened sometime between 1 and 2 years after construction. Subsequently, they should be checked on an annual basis. At least six should be checked at one site each year. Those being checked should be identified in the records so that alternate bolts can be checked in future maintenance operations.

5.4.5 Summary of Annual Maintenance Procedures

The following is a summarised list of the preventative maintenance items to be carried out during the annual routine maintenance of SLT decks. More detailed information is contained in the previous sections, as referenced.

- deteriorated and/or cracked areas of the wearing surface should be repaired and resealed 5.4.3.2
- local depressions in the wearing surface should be filled 5.4.3.2
- damage to exposed areas of waterproofing membranes and deck edge flashing should be repaired 5.4.3.2
- deck surface drainage areas should be cleared of debris 5.4.3.3
- support bearings and sills below open deck joints should be cleared of accumulated debris 5.4.3.3
- prestress levels should recorded at least once a year 5.4.3.5
- the integrity of the anchorage protection system should be repaired as required 5.4.3.9
- tie down and end protection bolts should be checked 5.4.4

5.4.6 Three Year and Infrequent Maintenance

There are no specific three year maintenance requirements for SLT decks as the need for adjustments is based upon performance. In most instances, it is likely that very little maintenance will be required except for periodic restressing. Some additional considerations follow.

5.4.6.1 Prestressing Systems

Prestressing systems are designed to provide a long service life. However, in the existing bridges, the longevity of the prestressing tendons and anchorages is still being observed. It is possible that some style of prestressing tendons may require replacement at some point in the life of the deck as a preventative measure to avoid failure due to deterioration. However, this replacement is not expected to occur within at least 15 to 20 years from installation. Replacement of tendons is outlined in Subsection 5.5.
It should be noted that some forms of anchorage protection system will require replacement and/or upgrading at certain intervals.

5.4.6.2 Restressing of Tendons

Each SLT deck must retain a minimum pressure on the laminates to ensure an integral structural performance. For decks constructed of softwood timber, the minimum uniform pressure on the timber must not fall below 550 kPa. For hardwood timber decks the pressure must not fall below 700 kPa. The design drawings for all SLT bridges should specify the required minimum tendon forces based on the above pressures.

However, it should be noted that some SLT designs, using softwood timber designed and/or built prior to 1996 (before the lower 550 kPa level was introduced), used a minimum design pressure of 700 kPa. Therefore these bridges should have the minimum force levels, given on the drawings, lowered by about 20%. The SLT database, discussed in the subsequent section, will contain the updated tendon force levels, and should be referred to before any adjustments are made.

Restressing of a SLT deck should be carried out in accordance with the requirements of RTA Form 2115.

5.4.6.3 Records of Restressing

The initial tendon forces along with the final tendon forces should be recorded and forwarded to Bridge Engineering marked to the attention of the Maintenance Manager. This data should include the following information:

- bridge name, number and location
- date the work is performed
- tendon identification numbers for each recorded tendon force with reference to the numbering used in the SLT database
- general weather conditions and temperature
- equipment used including identification where applicable
- name of person performing the work

5.4.6.4 Prestressing Anchorage Protection

The nylon protective caps (see Figure 5.2.4.3-2) used with prestressing strands should be removed every six years and the grease protection renewed, if required. At least 5% of the total caps, but not less than 24, at any one site should be checked every three years. If these indicate that the protection is still intact, then no further work is required. However, the tendon identification numbers of those checked should be recorded and alternate tendons should be checked during subsequent maintenance operations. Where any deterioration
is discovered, all of the caps should be removed in turn and new grease should be applied to the anchorages, before the caps are secured back in place.

Some prestressing anchorages use only Denso tape (see Figure 5.7.4.3-1) or similar systems, as a protective measure. This should be replaced every six years depending on its condition, as it does dry out with time. Also, new tape should always be applied whenever the old tape is removed (during lift offs and/or restressing).

5.4.6.5 Deck Tie Downs and Deck Joints

Where a SLT bridge deck uses kiln dried hardwood, it is not generally expected that retightening of the bolts would be required for at least 10 to 15 years after the initial retightening (12 months after construction). However, softwood bridges may require retightening sooner. Regardless of the timber used, the bolts for both tie downs and deck joints should be checked every three years using a spanner to ensure that they remain tight.

At least 10% of the total number, but not less than 24, should be checked at each site and any loose bolts should be tightened. The bolts that are checked should be clearly identified in the records so that alternate bolts can be checked during subsequent maintenance operations. If more than 5% of the total number of bolts checked are loose, then all of the bolts in the bridge should be retightened.

It should be noted that the overall performance of the deck depends heavily on the integrity of the tie down system. A loose tie down system can cause overstress conditions and increased deck deformations leading to possible timber damage and break up of the wearing surface.

5.5 REHABILITATION AND REPAIRS

Section 1 covers the general aspects of rehabilitation and repairs to timber bridges. This subsection describes repair and rehabilitation works related specifically to SLT bridges.

Unlike the traditional timber bridge, a SLT deck rarely represents a danger when it has damaged timber components. A SLT design is based primarily on serviceability (deflection limits) and its actual strength usually exceeds the design loads by a reasonable margin. Therefore, a damaged SLT system will undergo extensive deformation before failure and so would create problems related to serviceability rather than safety. In most cases, there is no immediate danger and damaged components are usually scheduled for replacement rather than being repaired immediately.

In this regard, unlike the other sections, this section does not differentiate between temporary repairs and component replacement.
5.5.1 Wearing Surfaces and Protection Systems

The wearing surface on the majority of SLT decks uses a rubberised asphaltic concrete or rubberised bitumen flush seal as described in Subsection 5.2.4. Some bridges, however, contain a waterproof membrane combined with a conventional bitumen wearing surface. The repair or replacement of these two types of surface must be handled differently.

5.5.1.1 Rubberised Asphaltic Concrete

Minor damage to wearing surfaces should be dealt with during preventative maintenance operations as described in Subsection 5.4.3.2.

Replacement of a thick rubberised wearing surface on a SLT deck can be carried out in a similar manner to that on concrete deck bridges. The existing surface can be milled to remove the majority of material. Care should be taken not to damage the timber deck and the flashing materials at the sides and ends of the deck. Asphalt in the latter areas may require removal by hand. The remaining material should be inspected for any loose areas and these should be removed. Subsequently, a new rubberised wearing surface can be applied.

5.5.1.2 Rubberised Flush Seals

Minor damage to wearing surfaces should be rectified during the preventative maintenance operations described in Subsection 5.4.3.2.

Generally, the need for a new flush seal surface on a SLT deck arises from extensive wear where the timber deck begins to show through. At this point, it is not necessary to remove the old surface except for any loose areas. A new rubberised flush seal should be applied directly on top of the old surface.

Where an existing surface has been built up through several applications, the thick areas can be milled similar to an asphaltic concrete surface.

5.5.1.3 Conventional Wearing Surface with Waterproof Membrane

Minor damage to wearing surfaces and areas of exposed membrane should be rectified during preventative maintenance operations, as described in Subsection 5.4.3.2.

Replacement of a thick wearing surface may be carried out, as described in Subsection 5.5.1.1, by milling to remove the majority of the material. Extreme care must be taken not to damage the waterproof membrane. Any damage to the membrane must be repaired before the new conventional surface is applied.
Where the membrane protection is seriously damaged, or its integrity cannot be assured, a new rubberised bitumen wearing surface is to be applied to provide the necessary waterproofing. The existing membrane may be left in place except where moisture ingress under the membrane is suspected. In this case, the membrane should be completely removed.

5.5.2 Timber Decking

While rare, it is not particularly unusual to find a fracture in an isolated timber laminate in a SLT deck. Due to the nature of the derivation of the design strengths for these decks, details of which are beyond the scope of this manual, one laminate in several hundred may be weaker than the load it experiences. As such, it will have an insignificant effect on the strength and performance of the deck. Therefore, while it should be noted and reported, it would not necessarily require replacement.

If more than one or two laminates in a SLT deck are fractured, then a detailed engineering evaluation should be carried out to determine the cause.

Typically, timber laminates in a SLT deck cannot be easily repaired or replaced. Since the deck is under prestress pressure, it would be necessary to destress it in order to remove and/or replace any broken laminates. Such repairs and/or replacement should only carried out with proper engineering support and a specific procedure designed for that particular bridge.

5.5.3 Prestressing System

While the prestressing systems in SLT bridges are similar, there are several different types of prestressing tendons as well as anchorage systems. Damaged or deteriorated prestressing tendons and anchorages (excluding the anchorage plates) cannot be repaired. They should be replaced as soon as they are observed and replacement should be performed by approved personnel only, using approved equipment.

While the following outlines some important considerations, a properly engineered replacement procedure should be developed for each specific SLT bridge.

5.5.3.1 Replacement Single Prestressing Tendons (Under Traffic)

Replacement of a single tendon (or multiple tendons one at a time) may be carried out under traffic as long as certain conditions are satisfied.

The minimum prestress level in the adjacent tendons must be high enough to ensure that the assumed average prestress pressure on the timber does not fall below the minimum level specified in Subsection 5.4.3.7. This assumes that the
forces in the two tendons (one on either side of the one being removed) act over the three locations.

With release of one tendon, the adjacent tendons will experience a slight increase in force due to the elasticity of the timber deck (usually not more than 15-20%). Therefore, it is important to ensure that the maximum prestress level in the adjacent tendons does not exceed the maximum design jacking force specified on the design drawings. Tests should be performed in several locations where the adjacent tendon forces are monitored during release of a tendon. Subsequently, the adjacent tendons can be adjusted to a level which will ensure the forces remain within the, minimum and maximum, during the replacement procedure.

If multiple tendons are deteriorated or damaged and cannot be safely set at levels to maintain adequate prestress during replacement procedures, then the bridge should be closed to traffic. However, with proper engineering evaluation, it may still be possible to continue the work under light traffic only.

5.5.3.2 Replacement and Release of Multiple Tendons

Where multiple tendons are to be released, the road should be closed to traffic. Generally, the replacement of multiple tendons should still be carried out as outlined in Subsection 5.5.3.1. Unless timber decking is to be removed or replaced, a SLT deck should be fully released over more than one or two tendons at a time. Release of multiple tendons requires a careful and time consuming process, as outlined below, which can become uneconomical.

Where multiple tendons are to be released, it is extremely important that the adjacent tendons (which are not being released) are monitored to ensure they do not become overstressed. In general, the detensioning should be performed in stages (eg: 75%, 50%, 25%) where all tendons are destressed to the same level before continuing to the next level. This will also ensure that the differential prestress forces are minimised, thereby reducing potential distortion of the deck and anchorage bulkheads.

The deck will expand perpendicular to the laminates when the prestress pressure is reduced. Therefore, it will be necessary to release deck tie downs at the extremities of the deck during the procedure to minimise lateral forces on these components.

Restressing of a SLT deck should be performed in accordance with the procedures for new SLT decks as specified in RTA Form 2115.

5.5.3.3 Prestressing Equipment

Certain precautions should be observed when stressing or destressing tendons and these include the following:
• the equipment must be calibrated and be supplied with a recent calibration chart in accordance with RTA Form 2115
• only approved adaptors supplied for that specific prestressing tendon should be used
• the tendon design forces and maximum jacking forces should be known and the latter should not be exceeded under any circumstances
• the work must be supervised or performed by approved personnel only

5.5.3.4 Grease Protection (Prestressing Bars)

All prestressing tendons in SLT decks have protective grease injected into the void around the tendon. Bridges using prestressing strands incorporate an additional polyethylene conduit which separates the strand from the grease as will be discussed in the next section.

In the case of prestressing bars, the grease is in direct contact with the bar. Therefore, removal/replacement of the bars will remove some of this grease and it will be necessary to inject additional grease for protection. This is performed via a long injection hose inserted into the hole in the deck (when the bar has been removed) as shown in Figure 5.5.3.4-1.

The hose should be inserted into the deck and be long enough to reach within 1 m of the other side of the deck. Once the grease pump is activated, the hose will begin to eject (itself) from the deck as the grease is pumped into the void. The greasing process is usually stopped when the end of the hose is within 1 meter of the edge of the deck at the entrance hole. Note that the hose should be marked so that the 1 m length is clearly visible. Subsequently, when the bar is reinserted in the deck, it should displace the grease so that some grease is ejected on both sides of the deck by the time the bar is fully inserted. This ensures that the void is completely filled with grease. Care should be taken to collect any discharged grease in order to protect the environment.

![Grease Injection Tube - Pound Crossing Bridge](image-url)
5.5.3.5 Prestressing Strand Protection

Prestressing strands are typically greased and then sheathed in a protective polyethylene conduit by the manufacturer. The strand, along with the conduit, are installed in the SLT deck as one unit. A sleeve and flange arrangement is used in the anchorage areas to complete the protection system. An approved system is detailed in RTA Form 2115. Grease is still injected into the void surrounding the conduit. However, the grease is not disturbed when a strand is subsequently replaced as the conduit is not removed.

Extreme care should be taken when inserting a new strand into an existing conduit in order not to damage the soft polyethylene material. The end of the strand being inserted should be ground smooth to remove any sharp edges.

If the end polyethylene flanges and/or sleeves are removed, care should be taken to ensure the grease in the anchorage areas is retained, or additional grease is injected as required.

5.5.3.6 Prestressing Anchorage Plates and Bulkheads

Typically, the heavy steel components of prestressing anchorage systems are galvanised and the only repairs required will be to touch up the galvanised protection. Heavily rusted or unprotected steel components should be cleaned and painted.

Damaged or distorted components should be properly investigated to determine the cause of the damage. Components should be replaced with the same sections and sizes only if the damage was not caused by the prestressing force and it is clear that the condition will not recur.

Where it is suspected that the anchorage system is overstressed due to the prestressing forces, a detailed engineering investigation should be carried out. This investigation should produce the details for a new anchorage system.

Replacement or repairs requiring the removal or destressing of tendons should be performed in accordance with Subsections 5.5.3.1 and 5.5.3.2.

If damage has been caused by flooding or other seasonal events and/or the prestressing tendons are at risk, then additional protection should be provided.

5.5.4 Deck Tie Downs

Typically, the steel components of deck tie downs are galvanised and the only repairs required will be to touch up the galvanised protection. Heavily rusted or unprotected steel components should be cleaned and painted.

Damaged or distorted components should be properly investigated to determine the cause of the damage. Components should be replaced with the same
sections and sizes only if the damage was not caused by traffic or the prestressing forces and it is clear that the condition will not recur.

Where it is suspected that the tie down system is overstressed due to traffic or the prestressing forces, a detailed engineering investigation should be carried out. This investigation should produce the details for a new tie down system.

If damage has been caused by flooding or other seasonal events and it is suspected that the condition might recur, then additional protection should be provided if possible. If it is not possible to protect the exposed components, it may be necessary to provide heavier components. Alternatively, it may be necessary to redesign and replace the system so that the components are not exposed.

Usually it is acceptable to release one or two tie downs at a time and allow traffic on the SLT deck. However, there is a wide variation in the number of tie downs that may be used in a SLT deck depending on its size and the details of the supporting components. Therefore, an approved procedure should be developed for a specific bridge.

5.5.5 Deck Joint Assemblies

Typically, the steel components of joint assemblies attached to SLT decks are galvanised and set into rubberised epoxy to ensure even bearing. The only repairs required will be to touch up the galvanised protection and retighten the bolts. Heavily rusted or unprotected steel components should be cleaned and painted.

Damaged, distorted or loose components should be properly investigated to determine the cause. Components should be repaired or replaced with the same sections and sizes only if the damage was not caused by traffic, or the prestressing forces, and it is clear that the condition will not recur.

Where it is suspected that the joint has been damaged by traffic or affected by the prestressing forces, a detailed engineering investigation should be carried out.

If damage or loosening has been caused by traffic and it is suspected that the condition might recur, then it may be necessary to provide heavier components.

Steel plates and sections of joint assemblies should be reseated in a layer of rubberised epoxy and tightened immediately before the epoxy sets. The joint should be protected from traffic until the epoxy has fully cured.

5.6 ENGINEERING DESIGN AND EVALUATION

Section 1 outlines the basic information for the engineering design and evaluation of timber bridges. It mentions the general specifications applicable to
the design of timber bridges in NSW and provides some relevant interpretation.

This subsection briefly introduces the current RTA guide applicable to the design of SLT decks and reviews some of the recent changes to that guide.

5.6.1 RTA Design Guide for SLT Decks

The design guide for SLT decks, as specified in Subsection 5.8, was developed and published by the RTA in 1995 and updated in 1999. It covers the design requirements for stress laminated timber plate decks in limit states format using hardwood, softwood and laminated veneer lumber (LVL). This specification shall be used as the basis for the design and evaluation of all SLT decks.

The original RTA specification (1995) covered only the following SLT design types and components:

- plate decks (ie: single level deck system)
- decks composed of (kiln dried) hardwood, (treated) softwood or (treated) LVL
- the use of prestressing bars

However, since its publication, some significant developments have been introduced including the use of prestressing strands and green hardwood [3]. Also, with the publication of the new AS1720 (1997) in limit states format, a considerable portion of the original design information is no longer required as reference can (and should) be made to AS1720. The revision of the RTA Design Guideline (1999) includes the following new features:

- design of decks composed of green hardwood
- use of prestressing strands and protection systems (now preferred)
- requirements for grease injection protection
- reference to AS1720 (1997) for timber properties, strengths, design capacity formulations and related modification factors

Basically, the revised design guide provides the following design features:

- requirements for deck laminate detailing including butt joints and prestressing holes
- procedures to determine load distributions for the SLT deck and factored load effects using Austroads design loads
- procedures to design the prestressing system including anchorages, bearing plates and distribution bulkheads.

5.6.2 Design Loadings

All elements of a SLT deck and components shall be designed to satisfy the loadings specified in Section 2 of the 1992 Austroads Bridge Design Code.
5.6.3 Design Features

While the RTA Design Guide provides detailed specifications and guidance for the design of SLT decks, the following outlines some of the important design features of SLT bridges. In addition, Subsection 5.7 provides some typical design details for SLT decks.

5.6.3.1 Timber Selection and Availability

The primary objective in selection of the timber is to determine the optimum depth of a SLT deck which provides an economic balance between (timber) material quality and section size. In this regard, it should be noted that the design of most SLT decks will be governed by the serviceability (ie: deflection) limits imposed in the design guide. The strength of the timber at the ultimate limit state will usually be considerably more than needed.

In this regard, it is important to evaluate a range of design options with specific emphasis on comparing the design, costs and availability of using different material grades and section sizes. For example, it is possible to increase material sizes (to increase stiffness) while lowering the material grade. The latter may not be particularly less expensive, but the timber may be more readily available.

In all cases, the designer should check the current availability of timber sizes and grades applicable to SLT decks before choosing the timber to be used in the design.

5.6.3.2 Prestress Tendons and Restressing

The design guide provides the detailed requirements related to the prestress levels which must be achieved and maintained in a SLT deck. It also provides guidance on the selection and design of the prestressing system.

However, it is important to note that the long term retention of prestress is a function of the flexibility of the prestressing system, particularly the prestressing tendon. Therefore, while the design guide provides a range of acceptable tendon properties, the designer should attempt to provide the most flexible system. Otherwise, the bridge will require restressing more frequently.

Currently the most flexible prestressing tendon available is prestressing strand which, for the same tendon force, can be stressed (or stretched) much more than a bar. This introduces more elasticity into the system to offset the long term compression of the timber. The latter stems from the fact that the strand material is generally higher strength (1800 MPa plus) compared to bars (1000 MPa plus) and therefore provides more stretch for the same force. This assists in offsetting the effects of long term compression (creep) of the timber, thereby retaining a higher prestress level for a longer period.
5.6.3.3 Prestress Anchorage and Distribution Systems

The type of prestressing anchorage and distribution system also plays a significant role in the long term performance of a SLT deck. This includes the retention of prestress levels as well as durability.

As previously noted in this section, the recommended prestress anchorage and distribution system is the plate and channel system as shown in Figure 5.6.3.3-1. This system reduces local deformation under the anchorages which can cause additional prestress losses. It also assures an improved alignment along the sides of a SLT deck by reducing differential deformation between anchorage points. This is particularly important for decks which are to be prefabricated and then fitted in place with limited clearances.

![Figure 5.6.3.3-1 Prestressing Anchorage Plate and Channel-Wakool River Bridge](image)

5.6.4 Composite SLT Bridges

At this time, the use of composite SLT designs is still limited and no specific design guidelines have been developed. The previous requirements related to inspection, maintenance and repairs can be applied to the existing prototype cellular SLT bridges.

5.6.5 Green Hardwood SLT Decks

The use of green hardwood in SLT decks is a recent development [3] and the first prototype bridge is still being monitored. However, the results have indicated that this form of SLT deck is a viable alternative to the use of kiln dried material. This alternative will provide a larger supply market for hardwood timber for SLT bridges. This in turn will improve availability and possibly lower material costs.

The use of green hardwood introduces several new design considerations when compared to the traditional use of kiln dried hardwood. These are directly related to the fact that green hardwood will have lower stiffness and strength as
well as increased long term shrinkage potential. This affects the design of the following features;

- deck depth
- prestress anchorages
- prestress levels
- restressing cycles
- waterproofing

5.7 DETAILING AND DURABILITY

This subsection provides a number of recommended details for common SLT deck and components. Particular emphasis is given to proven details for deck laminate layouts, prestressing anchorages, tendon arrangements, tie downs and deck joints.

5.7.1 General

While the basic design of all SLT decks is similar, detailing can vary significantly depending on the application and materials. No specific standard dimensional details have been developed, although some basic detailing requirements can be applied.

5.7.2 Wearing Surface and Deck Protection

The wearing surface and deck protection system is usually combined with other drainage components to provide drainage and protect the SLT from moisture.

5.7.2.1 Wearing Surface and Waterproofing

Waterproofing membranes have been used such as rubber sheeting, as shown in Figure 5.7.2.1-1. The membrane protects the deck against moisture and is overlayed with an asphalt surface. However, the typical waterproofing used on most SLT decks is a rubberised bitumen wearing surface where rubber is dissolved into the hot bitumen.
The most popular wearing surface is a thin flush seal which provides a finished surface which is approximately 20 mm to 25 mm thick.

The typical specification is as follows:

- Double/Double 14/10 Flush Seal with 20% Crumb Rubber

The rubberised bitumen wearing surface waterproofs the top timber surface and should be combined with flashing at the ends and sides of the timber deck, as outlined in subsequent sections.

### 5.7.2.2 Edge Flashing

The sides of SLT decks are also provided with flashing to keep the exposed timber dry. This flashing can consist of galvanised sheeting, as shown previously in Figure 5.2.2-3, where the flashing is extended from the top of the deck out over the anchorages and bulkheads. Alternatively, a soft rubber material can be used which is placed under the anchorages as shown in Figure 5.7.3.2-1.
In both cases, the flashing must be extended on top of the deck and sealed to the timber. In the case of a membrane waterproofing system (Figure 5.7.2.1-1), the edge flashing should be joined or sealed to the membrane.

Where a rubberised bitumen wearing surface is used, the flashing should extend far enough onto the deck so that the wearing surface overlaps the flashing by at least 100 mm. A typical detail is shown in Figure 5.7.2.2-2 for galvanized flashing on a SLT deck (which will have a kerb).

![Figure 5.7.2.2-2 Typical Flashing Detail](image)

5.7.2.3 Deck End Flashing

Flashing should also be applied at the ends of a SLT deck. However, it should be combined with the deck joint details as outlined in Subsection 5.7.6.

5.7.3 Timber Deck

The layout of the laminates and the holes for prestressing in a SLT deck are critical to its performance and specific requirements are set out in the RTA Design Guide. However, while trying to satisfy these requirements, it is also essential to properly use the commercially available timber sizes. The variables which play a role in design/detailing of a SLT deck should first be reviewed.

The basic variables include:

- frequency of butt joints (design requirement)
- prestress hole spacings (design requirement)
- commercially available timber lengths and section sizes

5.7.3.1 Available Timber Sizes

The thickness of laminates for SLT decks is limited to a maximum of 75 mm although typically 35 mm has been used for most bridges.
Laminate widths (= depth of the SLT deck) are available from 140 mm to 290 mm, typically in 50 mm increments, however 290 mm is difficult to obtain. The most common sizes are 140 mm and 190 mm and sometimes 170 mm has been used. It is even possible to use less than 140 mm. However, this is not specifically covered by the RTA Design Guide.

Timber lengths are available in 300 mm increments, (eg: 2400 mm, 2700 mm, 3000 mm) and it is critical to account for this in the detailing of a SLT deck. The butt joints and hole spacings should therefore be divisible by 300 mm.

5.7.3.2 Butt Joint Frequency Laminate Layouts

Design requirements limit the frequency of butt joints in a SLT deck to 1 in 4 at 900 mm spacing for both softwood and hardwood decks. A typical layout for 1 in 4 at 1200 mm spacing is shown in Figure 5.7.3.2-1. This means that along a line perpendicular to the laminates, the butt joints can be in every 4th laminate and the lines of butt joints should be spaced along the deck at 900 mm minimum intervals.

To satisfy a 1 in 4 frequency at 1200 mm spacing means that the average laminate length must be 4800 (ie: 4 x 1200). A 1 in 5 frequency at 1200 mm spacing would require an average laminate length of 6000 mm (ie: 5x1200).

![Figure 5.7.3.2-1 Plan View of Butt Joint Requirements](image)

As previously mentioned, it is necessary to use standard lengths of the timber for economic reasons. Otherwise it will be necessary to cut the standard lengths to suit, while still paying the cost of the standard lengths. For example, a design which used a majority of 4900 mm lengths of timber would be cut from 5100 mm lengths and represent a wastage of 4%.

In line with this, for a large deck, it is not economical to detail the laminates so that the majority are all one length as shown in the first diagram in Figure 5.7.3.2-2. Suppliers will generally not be able to provide 100s of one particular length. The second diagram in Figure 5.7.3.2-2 shows a layout using 3.6 m and 6 m lengths which still average 4.8 m and still distribute the butt joints to suit the limiting requirements. These two layouts can be combined to
use 3.6 m, 4.8 m, and 6 m lengths of timber which at least provides a range of three sizes. It should be noted that this represents only one layout and there are many other possible arrangements.

![Figure 5.7.3.2-2 Plan of Typical Laminate Layouts](image)

One additional detail should also be considered in relation to very long SLT decks. The material fabrication specifications, which are outlined in Subsection 5.8, allow a reasonable tolerance on the laminate lengths and hole locations for fabrication. Therefore, it is important to consider this in the detailing of the laminated deck. Typically, a gap should be detailed into the deck at each butt joint as shown in Figure 5.7.3.2-2, for long decks. This allows a laminate to be positioned so that the holes align and eliminates the possible cumulative problems that can occur if the laminates are slightly longer than the nominal length.

This nominal butt joint gap should be applied to decks with lengths (parallel to the laminate direction) which exceed:

- 10 m for decks with 1 in 4 butt joint frequency at 900 mm spacing
- 15 m for decks with 1 in 4 butt joint frequency at 1200 mm spacing

Interpolation should be used for designs in between these lengths.

### 5.7.3.3 Prestress Hole Spacing

There are a number of limitations on the hole spacing (Sp) contained in the RTA Design Guideline. These include:

- $Sp$ is a function of edge distance $D_e$ to wheel location
- $6d \geq Sp \leq 1200$ (d = depth of deck)
- $Sp \geq 2d$
- $Sp \geq 15$ times diameter of holes

Generally, none of the former plays a significant role in determining the hole spacings. The typical hole spacings are usually multiples of 300 mm, in line with
the laminate lengths, to provide a repeating pattern of laminates to facilitate fabrication and construction. For example, a design which used standard lengths (multiples of 300 mm) and a hole spacing of say 1000 mm would result in the holes falling in different locations along the length of every laminate. While this would be feasible, there would be literally dozens of different laminates which would increase fabrication costs and make construction difficult.

The most common hole spacings are 600 mm, 900 mm and 1200 mm for the deck layouts using 1 in 4 butt joints at 1200 mm or 900 mm spacing.

The overall length of a SLT deck will rarely be exactly a multiple of a standard layout (ie: 300 mm increments). Therefore, at the ends of the deck it may be necessary to vary the end distance to the last holes. The effects of this variation can be ignored if the end distance is within 10% of the required Sp/2. Otherwise, the prestressing force in the last tendon should be adjusted accordingly.

5.7.4 Prestressing System

While there are no specific design details for prestressing systems applicable to all SLT bridges, there are some general features which should be considered.

5.7.4.1 Prestressing Tendons

There are a several manufacturers of prestressing tendons (both bars and strands) in Australia, all of whom provide slightly different sizes and material properties. They also provide proprietary anchorages as well as anchorage plates in some cases. As such, it is not appropriate to suggest any particular type of tendon except to say that prestressing strands have proven to be the most effective as outlined in Subsection 5.6.3.2.

5.7.4.2 Prestress Bearing Plates and Bulkheads

The prestressing anchorage system includes the bearing plates and the specific protection devices used.

Prestressing anchorage systems can vary from the typical steel plate system shown in Figure 5.7.4.2-1 to stiffer systems using steel channels as shown in Figure 5.7.4.2-2.
Typically, simple steel plate anchorages are used only on kiln dried hardwood decks where the timber has a reasonably high strength to support the high prestress forces. Usually the anchorage systems for softwood and green hardwood decks require heavier steel plates or steel channels. However, current practice is for steel channels to be used on all types of SLT decks as they ensure improved performance as outlined in Subsection 5.6.3.3. The sizing of these elements is based on the specific design procedures outlined in the RTA Design Guideline.

The protection devices provided for the exposed prestressing anchorages include protective coatings (Denso tape see Figure 5.7.4.3-1) and nylon caps applied over strand anchorages as shown previously in Figure 5.7.4.2-2. All exposed anchorages must be protected against deterioration.
There are other internal protective systems for the tendons which are not visible such as polyethylene conduits and sleeves used for strands as well as the injection of grease into the voids surrounding the tendons inside the timber deck. Details are outlined in RTA Form 2115.

In addition to protection of the prestressing anchorages, some bridges also require protection restraint against physical failure of the prestressing. Figure 5.7.4.3-2 shows a steel restraint strap provided at the Abbotsford bridge which will hold back the anchorage in case of failure. This is required to protect the public as this lift bridge, when raised, would orient the anchorages along the roadway.

5.7.5 Deck Tie Downs

The tie down systems used for SLT decks vary depending on the support system. Due to the nature of a SLT deck, there are specific attributes which must be considered when detailing a tie down.
5.7.5.1 General Requirements

In general, tie down systems for SLT decks should be designed and detailed to accommodate several critical considerations. These include;

- provision of adequate tolerance to allow installation after the deck has been assembled and stressed together (this is particularly important for decks which are prefabricated and installed by launching or crane)
- allowance for future movements (perpendicular to the laminates) caused by creep and restressing of the deck
- sealing of top area against moisture ingress
- allowance for future retightening

5.7.5.2 Tolerance for Installation

Regardless of the type of SLT deck, it is critical to detail a tie down connection which will facilitate installation. Drilling of a SLT deck for bolts cannot be carried out until the deck has been properly stressed together. Therefore, holes are not predrilled in the timbers.

Once the deck is completed and in place, it is most efficient to drill the timber from the top. Therefore, it is difficult to drill through the deck to a very close tolerance and match a tight fitting hole in the flange of a steel beam, or other fixed component underneath the deck. Drilling from the underside is possible, but very slow and tedious.

As a result, the type of tie downs outlined in the subsequent sections are the most commonly used in the field.

5.7.5.3 Allowance for Future Movements

After the required initial stressing of a SLT deck, there are some subsequent small dimensional changes that occur (perpendicular to the laminates) over the long term. Some of these can be accommodated, usually by properly sizing the holes in the tie down components. However, it is also possible that restressing may be required at some future date which could introduce larger movements.

It is obvious that a rigid connection with a tight fitting bolt through the flange of a beam, as shown in Figure 5.7.5.3-1, would not allow much movement.
Figure 5.7.5.3-1  Rigid Tie Down Connection

In fact, this form of connection can restrain the prestressing effects on the timber deck, thereby affecting its performance. Therefore, a SLT deck should not be attached using bolts which are field drilled through the supporting member.

5.7.5.4 Top Tie down Washer Plates

Top plates are usually quite small and would be similar for all tie downs regardless of the SLT deck design. The top plates are rebated into the top of the timber deck, as shown in Figure 5.7.5.4-1, and sealed using a rubberised epoxy.

While the heads of the bolts are left proud of the timber surface, the wearing surface will usually be thick enough to cover them.

Figure 5.7.5.4-1  Top Tie Down Plates - St Albans Bridge

5.7.5.5 Simple Plate and Washer Tie Down

A simple form of tie down which can be applied to either timber or steel beams is shown in Figure 5.7.5.5-1. This tie down can easily be fitted in the field and provides considerable tolerance for the drilling of holes.

It also provides flexibility for future movement of the deck (as the deck narrows slightly). The exposed bolt (length) below the deck can lean slightly as the deck
moves without introducing undue stresses on either the deck or the bolt itself. However, it is not attractive and is rarely used where aesthetics are important.

![Plate and Washer Tie Down - Grafton Bridge](image)

**Figure 5.7.5.5-1** Plate and Washer Tie Down - Grafton Bridge

### 5.7.5.6 Steel Clip Plates on Steel Beams

Another typical type of tie down for a steel beam support is shown in Figure 5.7.5.6-1. This simple plate is detailed to clip under the flange of steel beams so that it applies pressure simultaneously to the deck and the steel flange.

![Steel Clip Plate on Steel Flange](image)

**Figure 5.7.5.6-1** Steel Clip Plate on Steel Flange

### 5.7.5.7 Angle Bracket Tie Down

An alternative type of tie down frequently used on either steel or timber (of rectangular cross section) comprises a steel angle bracket as shown in Figures 5.7.5.7-1 and 5.7.5.7-2. This bracket has an enlarged slotted hole, as shown in Figure 5.7.5.7-3, which allows some tolerance for drilling as well as future movements. It is usually welded to steel beams and bolted or coach screwed to timber members.
In the case of steel beams, where neoprene bearings are used under the timber deck, the bolted connection is detailed to provide small movements under load to facilitate rotation of the deck. This is achieved by introducing rubber mounting blocks as shown in Figure 5.7.5.7-2.

![Diagram of Angle Bracket Tie Down on Timber Beam]

Figure 5.7.5.7-1 Angle Bracket Tie Down on Timber Beam
Figure 5.7.5.7-2  Angle Bracket Tie Down on Steel SHS Beams

Figure 5.7.5.7-3  Angle Bracket Tie Down _ St Albans Bridge

The finished tie downs can be quite unobtrusive, as shown in Figure 5.7.5.7-4, and therefore do not affect the aesthetics of the bridge.
5.7.6 Deck Joints

Typically, the deck joints in SLT designs use thick steel plate to develop strength and durability. These joints are generally designed as open joints (see Figure 5.7.6-1) although some designers use compression seals (see Figure 5.7.6-2). Regardless of the design style, the performance of these joints is very important to the durability of the SLT deck.
Figure 5.7.6-2  Pound Crossing, Compression Seal Deck Joint

The basic detail of a typical deck joint is shown in Figure 5.7.6-3. A thick (20 mm to 25 mm) steel plate is used along with a steel angle at the end of the SLT deck. The plate thickness and the angle are chosen so that they require a slight rebate into the timber deck. The latter allows the levelling of the deck at that location to ensure a flat area. The two components are set into rubberised epoxy and securely bolted to the deck. The plate provides a dam to support the wearing surface and the angle protects the end of the deck from damage caused by foreign materials that may be driven into the open joint. Flashing is fitted behind the vertical leg of the angle and extended down below the deck as shown. This flashing can be extended down further to protect any other components which may be subjected to moisture coming down through the joint.
5.7.7 Deck Drainage

The majority of new SLT designs use open drainage with no kerb as shown in Figure 5.7.7-1. They are generally designed with either a built in crossfall of the deck or a bitumen wearing surface of a varying thickness to provide crossfall.

However, some deck replacements on existing steel bridges do not suit this arrangement as the water may be discharging onto the supporting steel members. In these cases, new kerbs are installed (see Figure 5.7.7-2) which...
are sealed against the deck using rubberised epoxy. The kerbs are combined with through-drains, as shown in Figure 5.7.7-3, to collect and discharge the water clear of the supporting steel members.

![Abbotsford Bridge, Sealed Timber Kerbs](image1)

**Figure 5.7.7-2**  Abbotsford Bridge, Sealed Timber Kerbs

![Abbotsford Bridge, Deck Pipe Drain](image2)

**Figure 5.7.7-3**  Abbotsford Bridge, Deck Pipe Drain

These through drains are relatively simple and a typical detail is shown in Figure 5.7.7-4. A steel plate is used to provide a top flange for the steel pipe and a threaded coupler is used under the deck to secure the pipe in place like a nut and bolt. The top flange plate is set into rubberised epoxy to seal against moisture and an extension pipe can be installed to discharge the water at any distance below the deck.
5.8 SPECIFICATIONS

Section 1 lists the relevant specifications applicable to timber bridge construction. This section identifies the specifications directly applicable to SLT bridges. These are listed below:

- Recommended Guide for the Design of Stress Laminated Timber Plate Decks, RTA (Bridge Engineering)
- RTA Form 2382 - Timber Supply - Hardwood for SLT
- RTA Form 2383 - Timber Supply - Softwood for SLT
- RTA Form 2381 - Construction of SLT Decks
- RTA Form 2115 - Stressing of SLT Decks

The design guide, which was derived specifically for SLT bridges, was outlined in Subsection 5.6.1.

RTA Forms 2382 and 2383 outline the requirements for the timber materials which will assure the quality and durability of the timber being supplied for SLT decks.

The last two specifications outline the important features of the construction and stressing of SLT bridges to ensure that the completed structure meets the intended performance requirements.

Design of the steel components for the prestressing, including the prestressing tendons, is covered in the design guide. However, the basic prestressing materials (which are similar to those used in prestressed concrete) are covered by Australian Standards AS1311, AS1313 and AS1314 as listed in Subsection 1.8.
5.9 MATERIAL SUPPLY

5.9.1 Materials

Unless specified otherwise on the design drawings, material requirements shall be in accordance with the RTA specifications outlined in Subsection 5.8. With new designs or major rehabilitation works, it is assumed that design drawings and/or specific construction specifications will be supplied.

5.9.1.1 Timber Supply - General

All timber components shall be ordered by specifying size, strength grade (ie: F17), finishing/conditioning (surface green or kiln dried) and durability class (or treatment hazard level for softwood, see Subsection 8). All timber shall be supplied in accordance with RTA Forms 2382 or 2383 Timber for Bridges - Stress Laminated Timber Decks, Hardwood or Softwood, respectively, as applicable.

5.9.1.2 Prestressing Materials

Prestressing materials shall be specified in accordance with the current AS1311 and AS1313 standards for prestressing bars and strands, respectively. Anchorages shall be specified to be in accordance with AS1314.

Both bars and strands should be identified specifically by the size and grade assumed in the design. It is not acceptable to provide a larger size tendon (of possible lower strength) than that specified in the design drawings as this will change the stiffness of the prestressing system. The latter will result in higher prestress losses.

In addition, prestressing strands shall be specified as 7-wire, stress relieved, high tensile super grade and low relaxation (to AS1313).

5.10 REFERENCES
