NOTE: JULY 2018

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 Some of the contents are out-of-date.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.

TIMBER BRIDGE MANUAL

Edition 1 Revision 0 – June 2008

SECTION SIX

TIMBER CONCRETE OVERLAY BRIDGES

TABLE OF CONTENTS

SECTION SIX

LIST OF FIGURES

6. TIMBER-CONCRETE OVERLAY BRIDGES

6. 1 GENERAL

6. 1.1 Scope

Section 6 covers the design, construction and maintenance of all traditional timber girder bridges with timber decking and sheeting which have been strengthened with a concrete overlay as outlined in Subsection 6.2.

This section is to be read in conjunction with Section 1- General, Section 4- Timber Girders, Decking and Sheeting and other sections as may be specified. Section 1 provides the basic requirements and procedures for the maintenance of all timber bridges and their components. Section 4 provides the basic requirements and procedures for the maintenance of timber girders, decking and sheeting and their components This section provides specific additional requirements relating to concrete overlays on timber girder bridges.

6. 1.2 Objectives

The objectives of this section are to outline the requirements of, and to provide guidance in relation to, the design, construction and maintenance of timber girder bridges with concrete overlays and their components with specific emphasis on:

- Inspection procedures
- preventative and routine maintenance
- rehabilitation and repairs
- engineering design and evaluation
- detailing and durability
- specifications
- materials supply

6. 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 *concrete overlay bridges.*

Concrete Overlay

A thin reinforced concrete slab cast on the deck of a traditional timber girder bridge

Concrete Overlay Bridges
A term referring to traditional timber girder bridge with a concrete overlay

Deteriorated/Deterioration
A term used synonymously to refer to damage caused by decay, insects or structural failure

Pour
Term referring to the operation of casting the concrete overlay

Shear Connector
Coach screws embedded in the top of the timber girders and decking and projecting up into the concrete overlay. Designed to provide some composite action between the timber and concrete

Slab
A term referring to the concrete overlay

Stage Construction
Where the overlay is cast in several stages with construction joints to allow the maintenance of traffic during the works

Tie Down
Vertical bolts passing through the timber girders and embedded into the concrete overlay to secure the overlay to the existing deck system

Traditional Timber Girder Bridges
Referring to the traditional timber girder bridges as defined in Section 4

6. 2 STRUCTURE TYPES AND COMPONENTS

A review of the common concrete overlays on a *traditional timber girder bridge* follows. This review provides a means of defining the terminology which will be used. Words in italics are noted to be the accepted terms normally used in the field when referring to the components or system under consideration. These terms are defined in Subsection 6.1.3.

6. 2.1 Traditional Timber Girder Bridge

A traditional timber girder bridge is shown in Figure 6.2.1-1 and Figure 6.2.1-2. The majority of timber girder bridges include round timber girders, transverse timber decking and longitudinal timber sheeting.

Figure 6.2.1-1 Typical Round Timber Girder Bridge - Wakool River

The traditional (original) bridges also incorporated timber kerbs, posts and rails as shown in these figures.

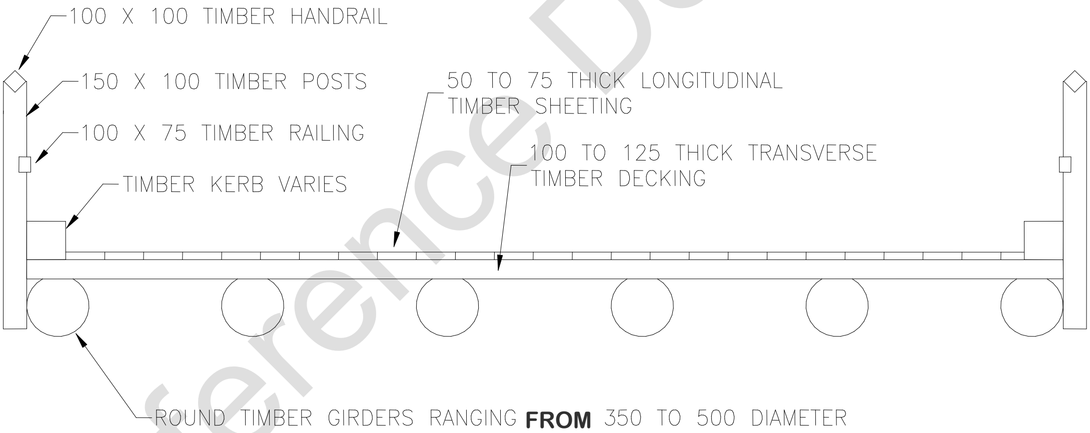

Figure 6.2.1-2 Cross Section of Typical Timber Girder Bridge

Additional details of the traditional timber girder bridge system are outlined in Section 4.

6. 2.2 Concrete Overlay

A *concrete overlay* basically comprises a lightly reinforced thin concrete slab varying from 75 mm to 125 mm in thickness. The slab is cast directly on top of the deck of a timber girder bridge with minimum modifications to the existing deck. The slab is formed to provide a minimum 1% crossfall, as shown in Figure 6.2.2-1, with no kerbs. The slab is fixed to the existing timber deck using coach screws and/or bolts which are attached to the timber components and project up into the concrete.

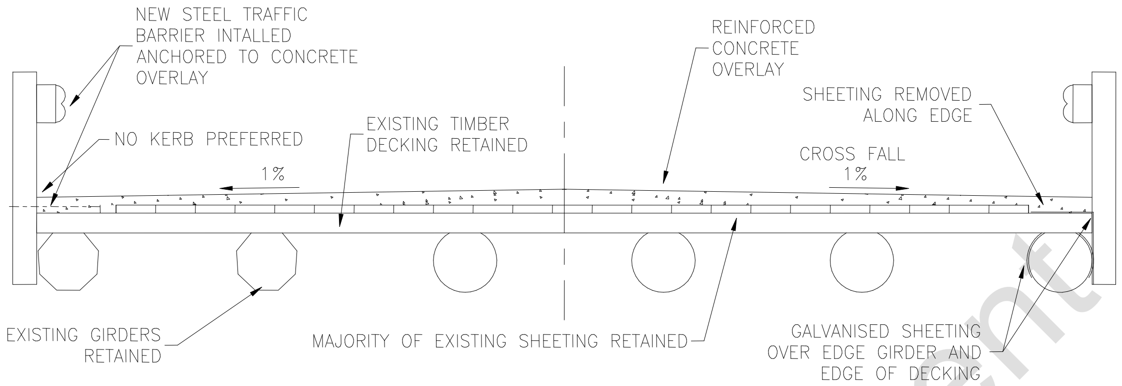

Figure 6.2.2-1 Traditional Concrete Overlay

6. 2.3 Traffic Railing and Kerbs

In most applications, a steel traffic barrier is introduced which provides superior protection compared to the traditional timber railing system. These barriers can be designed to meet Austroads standards and the posts are usually attached at anchorages cast directly into the concrete overlay, as indicated in Figure 6.2.2-1. Generally, kerbs are not provided to allow free drainage and promote raid drying, as well as eliminating possible ponding and collection of debris.

However, many Council and Shire bridges continue to retain the traditional timber kerbs as well as timber posts and railings, as shown in Figure 6.2.3-1.

Figure 6.2.3-1 Typical Shire Bridge Timber Kerb and Rail

6. 2.4 Modifications to Existing Bridge

The deck of the existing timber girder bridge usually undergoes minimum modification in order to maintain economy. Generally, the degree of modification depends on the amount of deterioration in the existing structure and the anticipated life of the refurbished bridge.

Any major timber components which are deteriorated, particularly the girders, are usually replaced. All connections are retightened and only the sheeting along the edges of the bridge is removed as shown in Figure 6.2.2-1. The girders and decking along the edges of the bridge are covered with galvanised sheeting to provide moisture protection (see Figure 6.2.4-1), as are the ends of the decking and the girders at the abutments.

Figure 6.2.4-1 Galvanised Sheeting

However, more recent developments have led to further modifications in order to enhance durability. These include removing the sheeting above the girders, installing stronger *tie downs* for the overlay as well as facilitating some composite action between the overlay and the timber using *shear connectors*. Additional details are outlined in Subsection 6.7.

6. 3 INSPECTION PROCEDURES

Section 1 outlines the basic inspection procedures for all timber bridge types and these procedures also apply to concrete overlay bridges. Section 4 outlines the specific inspection procedures relating to timber girder bridges which also apply to the timber components of concrete overlay bridges. This subsection highlights specific additional considerations for concrete overlay bridges and their components.

6. 3.1 Objectives and General Requirements

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

6. 3.2 Inspection Records

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

6. 3.3 Annual Visual Inspection

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

The visual inspection shall include:

- all exposed components of the timber girders, decking and sheeting where accessible
- surface of the concrete noting the location, size and extent of any cracking and/or spalling
- visible separation between the concrete overlay and the timber decking
- attention to the profile (level) of the deck with specific emphasis on any sag in girders or uneven deck surface
- observation of the girders and deck system under transient loading
- identification of any obvious structural defects and damage
- identification of any obvious deterioration
- indications of moisture leakage on the underside of the decking
- specific attention to previously reported problem areas in past inspection records

6. 3.3.1 Deck Profile

The overall level of the deck should be observed to detect any obvious sagging in the girders or deformations in the deck surface which could indicate deterioration in the girders or other defects. While the traditional timber girder bridges exhibit inherently uneven deck surfaces, the surface of a bridge with a concrete overlay should be very level except for the required crossfall. Uneven deck surfaces should be further investigated to determine the cause.

In cases where sag is evident, some measure of the profile should be obtained in order to establish a means of determining whether the condition is progressive when comparing with future inspections. A simple method of determining the profile using a string or wireline is outlined in Section 3 for trusses.

6. 3.3.2 Inspection Under Transient Loading

The basic requirements for inspection under transient loads are outlined in Section 1. Additional information related specifically to timber girder bridges is also provided in Section 4.

The following specific areas, as applicable to concrete overlay bridges, shall be observed for excessive movements and other considerations as noted:

- overall vertical displacement of the girders and deck between supporting members with particular emphasis on differentials between girders (ie one moving more or differently than others)
- apparent lateral or longitudinal movement of the deck
- local movements of the concrete overlay or decking indicating loose components
- visible movements of cracks in the concrete overlay
- movements at other connection details, particularly at the supports and corbels
- local deck movements under wheel loads. On concrete overlays, there should be no local deformation apparent around the wheel as a vehicle passes over the bridge
- signs of structural damage or deterioration which may be exposed during movements. This is particularly important at locations where there is cracking of the overlay
- movements at previously reported problem areas
- movements at previously repaired areas

6. 3.3.3 Structural Defects and Damage

All components and connections shall be visually inspected for obvious structural defects and damage. These should include:

- cracking and spalling of concrete
- member fractures due to loading, with particularly emphasis on girders at mid-span and longitudinal splitting at notches (section changes) near supports
- local crushing of timber at bearing points with particular emphasis on:
    - bearing points under girder
    - bearing between girders and corbels
    - top of girders supporting decking
- evidence of loose connections and/or enlarged holes around bolts, with specific emphasis on the tie down bolts for the decking system
- evidence of damage caused by vehicle collision with the railings and kerbs with specific emphasis on the attachments to the concrete overlay
- excessive sag in the girders or decking

Several typical structural defects and damage for timber girders, decking and sheeting are outlined in Section 4. One of the most typical forms of structural damage to the concrete overlay is transverse cracking over the piers as shown in Figure 6.3.3.3-1. Severe cracking is generally caused by inadequate reinforcement or excessive deflection of the bridge spans. Fine transverse cracks along the spans are also not uncommon on older bridges. However, longitudinal cracking and spalling represent serious signs of distress and will generally result in progressive deterioration.

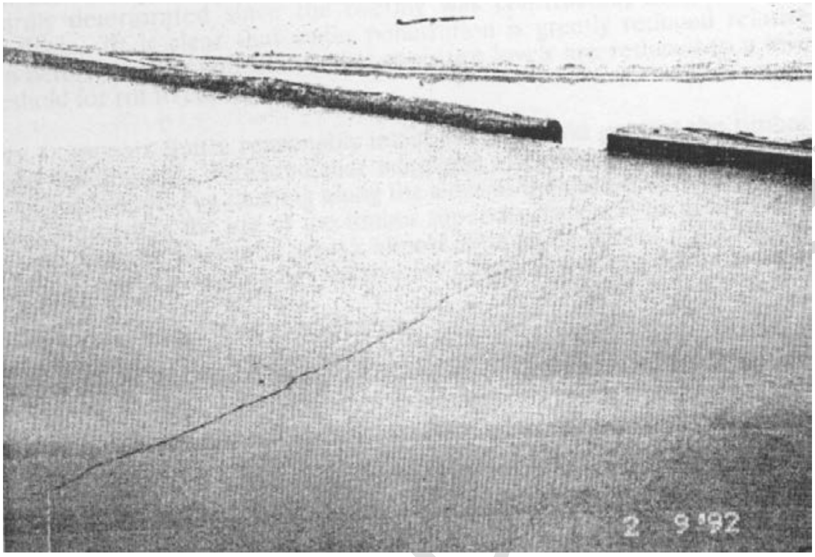

Figure 6.3.3.3-1 Typical Transverse Cracking over Piers

Some of the major causes of structural distress in a concrete overlay are:

- overlay too thin (over the piers) or too thick
- excessive flexibility (girders, planks)
- dynamic loading due to uneven surface or poor approaches
- deck components not tightened prior to overlay
- excessive amount of green timber used without adequate seasoning period prior to overlay
- very high frequency of heavy vehicle loadings (fatigue)
- lack of shear connectors and/or tie downs in the overlay
- deteriorated or damaged timber components
- movements at the supports

6. 3.3.4 Timber Deterioration

All girders, decking and sheeting shall be inspected for signs of deterioration caused by decay and/or insect attack. These should include:

- sapwood in any components particularly round girders
- areas where water is trapped or does not dry out readily with particular emphasis on:

- ends of girders
- bearing and (top) contact surfaces of girders
- interfaces between decking, sheeting and the concrete overlay
- holes at connections

- under flashing and behind other protective coatings
- ends of the deck system at abutments with particular emphasis on the areas of contact with the backfill

Some critical areas for deterioration in the timber are shown in Figure 6.3.3.4-1. The tops of the girders can develop deterioration at any location. The centres of the girders generally develop deterioration starting at the ends. The decking and sheeting will be particularly susceptible at the interface with the concrete overlay.

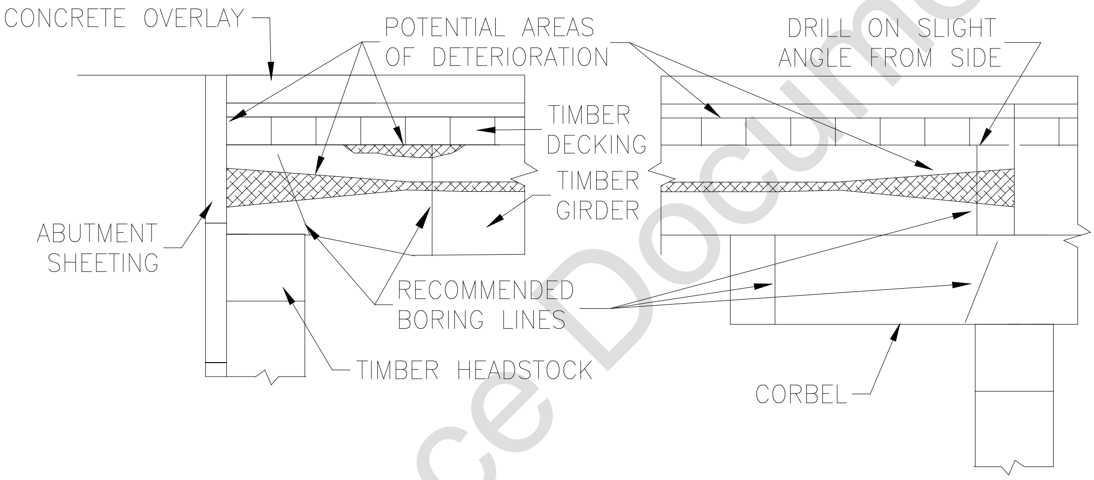

Figure 6.3.3.4-1 Typical Areas for Deterioration and Boring

It is important to note that the typical areas for deterioration are not usually apparent during visual inspection. However, serious internal deterioration may manifest itself through member crushing, deformations or visible movements at joints and connections.

Some typical examples of deterioration in timber girder bridges and their components are provided in Section 4.

6. 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 or penetrating (by boring) questionable areas with particular emphasis on:
    - under flashing
    - between timber interfaces
    - around bolts
- boring of main structural components including all girders

6. 3.4.1 Timber Boring

The standard methods and identification for timber test boring are outlined in Section 1 and shall be applied to the boring of the timber components in concrete overlay bridges. Boring shall be carried out, but not be limited to, the following areas:

- all timber girders at their ends (where the end is not exposed for visual inspection) as shown in Figure 6.3.3.4-1
- at locations which show visible signs of deterioration or crushing such as the tops of girders
- at the middle of girders if deterioration is found at the ends
- at the ends and middle of corbels
- spot checks in the decking and sheeting, particularly in areas where there are signs of leakage through the deck

Care should be taken to avoid drilling completely through the members except where deterioration is at the top of the member. Vertical holes which pass through a member should not be completely plugged to allow drainage. Horizontal bores should be inclined slightly upwards. All bore locations should be clearly marked on the members.

Where possible, bores should be perpendicular to the member surface so that the measurements outlined in Section 1 are relative to the section dimensions. However, at the ends of girders over supports, it is preferred that the vertical holes be inclined to reach over the support as shown in Figure 6.3.3.4-1. In these situations, the bore information is to be accompanied by the angle of the bore measured from the perpendicular (vertical).

Generally, boring of components with a minimum section of 100 mm or less should be limited. These members are usually too small to accommodate extensive internal deterioration without some external evidence. However, since it is difficult to access the timber near the bottom surface of the concrete, random checks should be carried out in the decking and sheeting. The checks should be adjacent to bolts, near the ends of components which are not exposed and where moisture leakage is observed.

The high risk areas are at the ends of girders and the contact surfaces between members.

6. 4 MAINTENANCE

Section 1 outlines the basic maintenance procedures for all timber bridge types and these also apply to concrete overlay bridges. Section 4 contains the basic maintenance procedures for timber girder bridges and these also apply to concrete overlay bridges This subsection highlights specific additional considerations for concrete overlay bridges.

6. 4.1 Objectives and General Requirements

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

6. 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 construction detailing outlined in Sections 1 and 4, Subsection 6.7 reviews a number of considerations specifically applicable to concrete overlay bridges.

6. 4.3 Annual Maintenance

Routine maintenance should be carried annually on all concrete overlay bridges as outlined in Section 1. This subsection reviews a number of considerations specifically applicable to concrete overlay bridges.

Routine maintenance should include:

- removal of fire hazards, with emphasis on grass and brush, from the proximity of the bridge
- removal of debris from the deck system and on top of members, particularly clearing any blocked drainage areas
- all bolted connections that are accessible should be retightened with particular emphasis on girder and corbel attachments
- <u>all bolts should be retightened 12 months after pouring of the overlay</u>
- retighten deck tie down bolts, particularly where movement is observed
- spot checks should be carried out on the less accessible bolts to determine whether further work is required
- preservative protection should be reapplied where possible and spot checks should be carried out on covered components to see whether further work is needed
- major cracking in the concrete surface should be sealed to prevent moisture ingress
- minor collision damage to railing systems should be repaired. Major damage should be reported and remedial repairs carried out if possible

6. 4.4 Three Year Maintenance

Every three years more thorough maintenance works should be carried out in conjunction with the detailed inspection as outlined in Section 1. This subsection reviews a number of considerations specifically applicable to concrete overlay bridges:

- retightening of all bolted connections including the deck tie down attachments
- exposing all hidden areas for retreatment
- difficult areas which cannot be exposed easily can be flooded with preservative (this must be performed with proper attention to protecting the environment)
- any severely deteriorated components should be replaced if possible and treatment should be carried out to arrest further deterioration
- seal all cracks in the concrete surface to prevent moisture ingress

6. 4.5 Treatment of Fungal and Insect Attack

The general requirements outlined in Section 1 should be applied to the timber in the girders, decking and sheeting of concrete overlay bridges and any fungal and insect infestation must be treated. A specialist should be engaged if damage is found. Simply replacing these members will not ensure removal of the infestation. It is important to determine the location of the termite (nest) source and have it removed.

6. 5 REHABILITATION AND REPAIRS

Section 1 outlines the general aspects of rehabilitation and repairs to timber bridges. Section 4 provides more specific details of the rehabilitation and repairs related to timber girder bridges. This subsection outlines repairs and rehabilitation related specifically to concrete overlay bridges and their components. In most cases, each typical component type is outlined in terms of both temporary (emergency) repair as well as component replacement.

The examples given are provided only as a general guide. The requirements at any particular site will depend on a variety of conditions. The term deterioration is used to refer to both deterioration and structural defects.

6. 5.1 Concrete Overlay

Serious cracks in the concrete overlay should be sealed to prevent moisture ingress. However, the cause of the cracks should be investigated in order to prevent further deterioration. As outlined in Subsection 6.4, transverse cracks, particularly at the supports, are not uncommon. However, longitudinal cracking indicates structural distress.

Spalling of the concrete also indicates serious structural distress and the cause should be determined and rectified. Minor spalling on the surface can be repaired using commercially available materials typically used on concrete bridges.

Major spalling should be repaired by removing the existing concrete to below the top layer of reinforcement in order to assure a good bond for the repaired area. High early strength materials with high adhesive properties should be used.

6. 5.2 Sheeting and Decking

Localised deterioration of timber sheeting and decking does not usually represent a serious problem unless the weakened system puts undue stress on the overlying concrete slab. While the concrete overlay has reasonable strength to bridge deteriorated decking, this is limited to small areas. As a rule of thumb, the following limits may be used as a guide to the maximum allowable localised deterioration where deterioration means the members do not support the components above:

- Where the decking supporting the sheeting is sound. No more than two adjacent sheeting planks shall be deteriorated (maximum width 300 mm) extending no more than 300 mm along the planks (ie: a 300 mm x 300 mm area)
- Where the sheeting above the decking is sound. No more than two adjacent decking planks shall be deteriorated (maximum width 400 mm). It is assumed that the decking provides no support between the girders.
- Where there is a combination of deterioration in both the decking and the sheeting, the maximum deterioration in the sheeting shall be as described above and only one in three decking planks shall be deteriorated in any one area (ie: both the adjacent decking planks must be sound)
- In general, the concrete overlay should not have to span more than 300 mm in any direction without direct firm support
- The concrete overlay should exhibit no localised cracking or spalling

Access to the decking and sheeting is restricted by the concrete overlay. Therefore, it is virtually impossible to replace the sheeting and decking. The concrete overlay prevents removal of the sheeting and only short lengths of decking can be removed from the underside of the deck (between girders). Therefore, only limited repairs are possible.

Repairs will have a limited life expectancy depending on the extent of the deterioration and the intensity of traffic loading. The following subsections outline some proposed methods of repair and replacement based primarily on traditional details.

6. 5.2.1 Repairs to Timber Sheeting

Where the deterioration in the sheeting is causing undue stress and/or structural damage to the concrete overlay, the following repairs can be applied from the underside of the deck.

Where the decking supporting the sheeting is sound:

- Clear as much soft material from the area as may be accessible
- It may be necessary to remove no more than one decking plank to gain access (to be replaced as outlined in Subsection 6.5.2.2)
- Seal around the area to prevent leakage (of the grout)
- Pump a cement grout into the void and allow to set before allowing traffic on the deck

Where the decking supporting the sheeting is also deteriorated:

- Remove the deteriorated decking between the girders
- Use the access to clear the deteriorated sheeting as may be accessible
- Where possible, drive hardwood blocking/wedges between any sound decking and sheeting to reinstate bearing support for the concrete overlay as much as possible
- Replace decking as outlined in Subsection 6.5.2.2
- Seal around the area to prevent leakage (of the grout)
- Pump a cement grout into the void and allow to set before allowing traffic on the deck

The life expectancy of these repairs will depend heavily on the extent of the damage, the quality of the repair and the extent of heavy traffic. Without removal of the concrete overlay, there are no other options available to repair the deteriorated sheeting. The only other option would be to remove larger sections of the decking in order to replace the sheeting. Subsequently, the decking would be repaired as outlined in the next section and then an additional girder could be installed between the existing girders to support the new decking and sheeting.

6. 5.2.2 Repairs to Timber Decking

Where deteriorated decking is reflected by distress in the concrete overlay, or has a potential to cause failure under heavy loads, it may be repaired as shown in Figures 6.5.2.2-1 and 6.5.2.2-2.

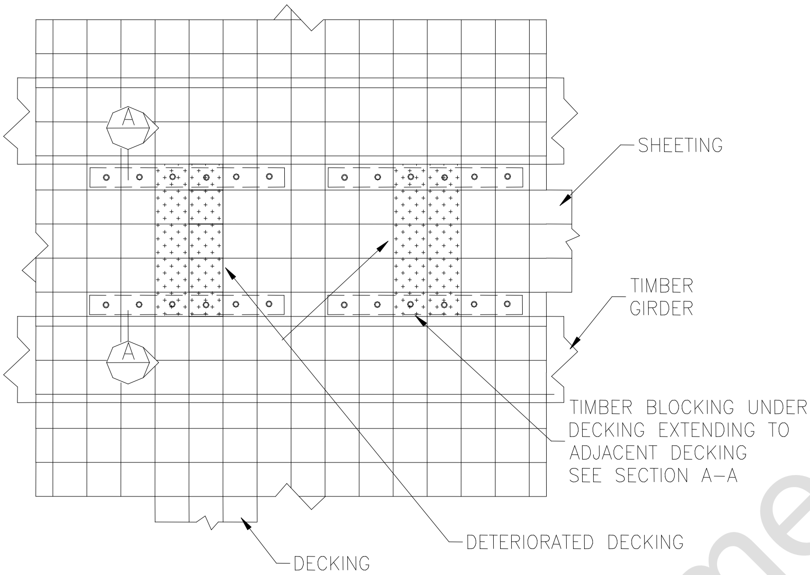

Figure 6.5.2.2-1 Plan of Decking Repair

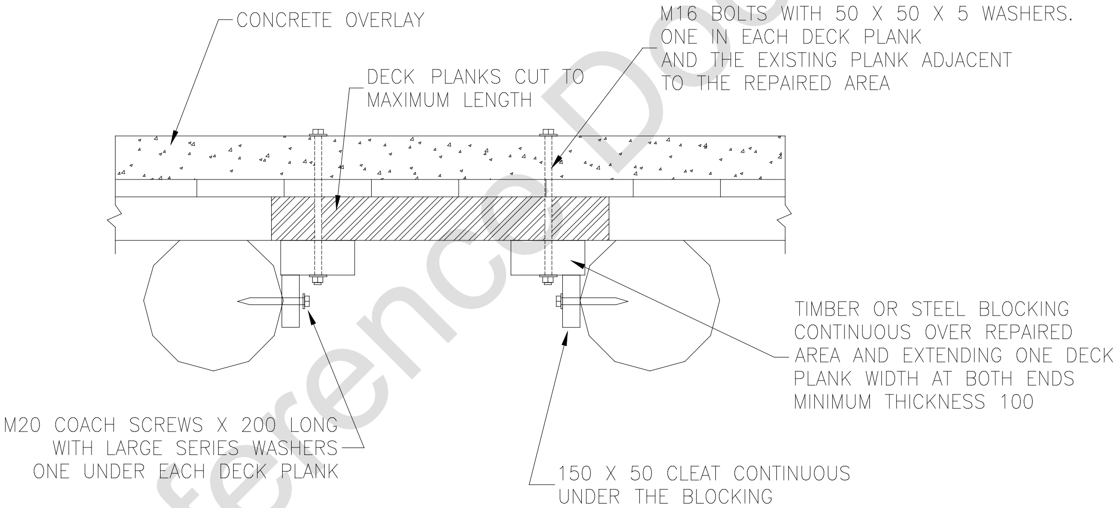

Figure 6.5.2.2-2 Section for Figure 6.5.2.2-1

The decking should be cut to maximum length between the girders for a tight fit. Continuous blocking of timber or steel should be used to attach the decking through the sheeting and the concrete. This blocking should also be extended to at least two of the adjacent existing decking planks as shown in Figure 6.5.2.2-1. Additional support should be provided by using timber cleats coach screwed to the sides of the girder as shown. The side of the girder should be flattened slightly to provide reasonable contact and the coach screws slightly staggered up and down.

The life expectancy of these repairs will depend heavily on the extent of the damage, the quality of the repair and the volume of heavy traffic. Without removal of the concrete overlay, there are no other options, aside from addition an extra girder between the existing girders to support the new decking components, available to repair the deteriorated decking.

6. 5.3 Timber Girders

Although the following information is directed towards the traditional round timber girder bridges, it is also applicable to square timbers.

6. 5.3.1 Temporary Repairs Using Posts (Toms)

Temporary repairs for damaged girders will depend on the site conditions. In cases where the bridge height is not excessive, it may be possible to install temporary toms under the girder to support the member as described for traditional timber girder bridges in Section 4. This method should not be used in poor ground conditions unless an engineering drawing is provided to ensure firm support. A concrete overlay bridge requires a more rigid support than the traditional girder bridge since it is much stiffer.

The temporary repair should be monitored daily until proper repairs can be carried out. After the first 24 hours, it is likely that shimming will be required for bridges subjected to heavy traffic as the timber bearing will compress into the ground. The prop must be tight and fully secured at all times to prevent damage to the other components.

6. 5.3.2 Additional Girders

As a more permanent measure, an additional girder can be installed directly adjacent to the damaged member. Unlike the traditional timber girder bridge, it is difficult to replace girders in these bridges and adding additional girders is the most practical method of strengthening.

Installation of additional girders should use the general procedure outlined in Section 4, for traditional timber girder bridges with the following modifications:

- the girder should be sized to provide a slight camber so that the middle of the girder contacts the deck first as it is jacked up against the deck
- the camber should be about L/300 where L is the girder length
- the girder should be bolted through the decking and the concrete overlay

As a total replacement for a damaged girder, this additional girder should not be considered to be a long term solution as it does not provide the correct load distribution. The existing adjacent girder on the other side will carry more load as the girder spacing (ignoring the old girder) is now larger, as discussed for traditional timber girder bridges in Section 4. Since it is not possible to replace the existing girder, as will be discussed in the next section, a longer term solution would be to add another girder on the other side of the damaged girder. This would relieve the potential overstress in the adjacent girder.

6. 5.3.3 Girder Replacement

Replacement of a damaged girder is very difficult for a concrete overlay bridge and, generally, additional girders should be installed as described in the previous section.

The basic procedure for girder replacement would be similar to that described in Section 4 for traditional timber girder bridges. However, that method requires that the existing deck be deformed by jacking in order to severe the existing attachment bolts. This deformation could damage the rigid concrete overlay. In addition, it would not be possible to expose the interface if coach screws are embedded in the top of the timber and cast into the concrete as outlined in Subsection 6.7.

6. 5.3.4 Strengthening and Upgrading

There is only one practical method for strengthening and upgrading an existing concrete overlay bridge and that is by the addition of additional girders as outlined in Subsection 6.5.3.2.

6. 6 ENGINEERING EVALUATION

Section 1 outlines the basic requirements for the engineering design and evaluation of timber bridges. Section 4 provides the basic requirements related to existing timber girders, decking and sheeting. This subsection highlights a number of considerations directly related to concrete overlay bridges.

6. 6.1 Design Specifications

Design of the original timber girder bridge and deck system components is governed by the requirements and loads specified in Section 2 of the Austroads Bridge Design Code. Design of the timber elements shall be in accordance with AS1720 as outlined in Sections 1 and 4.

6. 6.2 Concrete Overlay

The concrete overlay for these bridges has been developed through field trials based primarily on trial and error. As such, it is an empirical design with a limited basis in engineering calculations. Details of the concrete thickness, reinforcement and other factors are outlined in Subsection 6.7.

However, engineering evaluation of a concrete overlay would be based on the design loads specified in Section 2 and the capacities based on Section 5 of the Austroads Bridge Design Code.

6. 6.3 Timber Capacities

Basic determination of timber capacities using AS1720 is outlined in Section 1. More detailed information related to the timber girders, decking and sheeting is provided in Section 4 and shall apply to the timber components of concrete overlay bridges.

6. 6.4 Load Distribution for Concrete Overlay Bridges

Load distribution to the elements in traditional timber girder bridges is usually based on the simple assumptions outlined in Section 4. These assumptions are also applicable to concrete overlay bridges with the modifications outlined.

6. 6.4.1 Load Distribution and Assumed Span for Concrete Overlay

Generally, the concrete overlay is not specifically designed for a particular loading as its development is empirical in nature. However, in some cases, it may be necessary to evaluate an overlay due to deterioration or damage of the supporting deck system. In this case, only the decking directly in contact with the wheel should be assumed to carry the load.

The assumed span of the deck will be dependent on the site conditions and it is impractical to outlined the range of possibilities that could exist. Therefore, rational engineering judgement should be applied.

6. 6.4.2 Loads Distribution to Sheeting

Basically, it is assumed that the sheeting does not carry any direct loading as the concrete overlay is much stiffer than the timber sheeting.

6. 6.4.3 Load Distribution and Assumed Span Length for Decking

The distribution of wheel loads to the decking is similar to that described in Section 4. The number of deck planks sharing the load will depend upon the following variables:

- design load under consideration (ie T44 or W7)
- orientation of the decking (usually transverse , sometimes diagonal)
- depth of concrete overlay and sheeting (if present)
- width and depth of the decking

Most typical decking is transverse and, as a simple method of distribution, the load can be assumed to disperse through the deck at a 45^{o} angle as previously outlined in Section 4. However, the additional depth of the concrete would increase the distribution accordingly as shown in Figures 6.6.4.3-1 to

6.6.4.3-3. In this case, the width of the load distribution would be a function of the depth of the concrete and sheeting as shown in the figures.

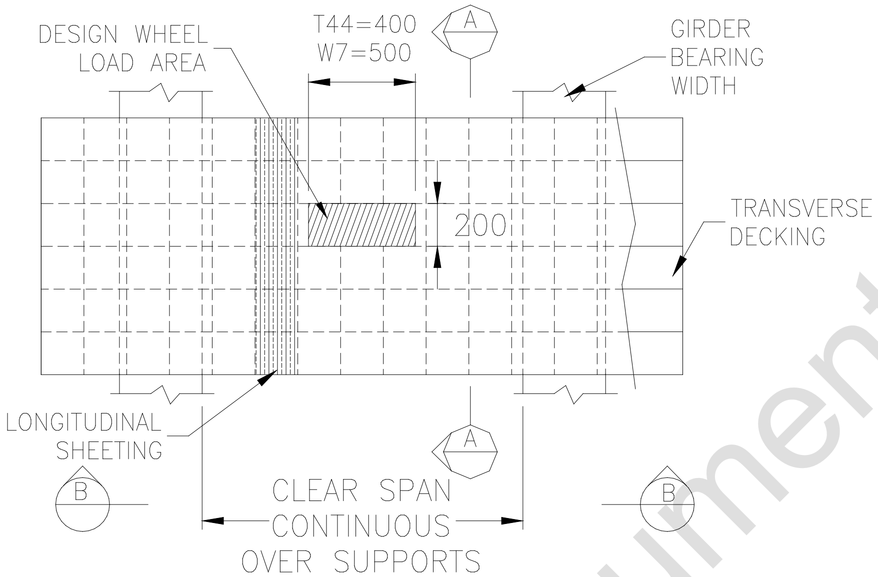

Figure 6.6.4.3-1 Plan of Design Load on Deck

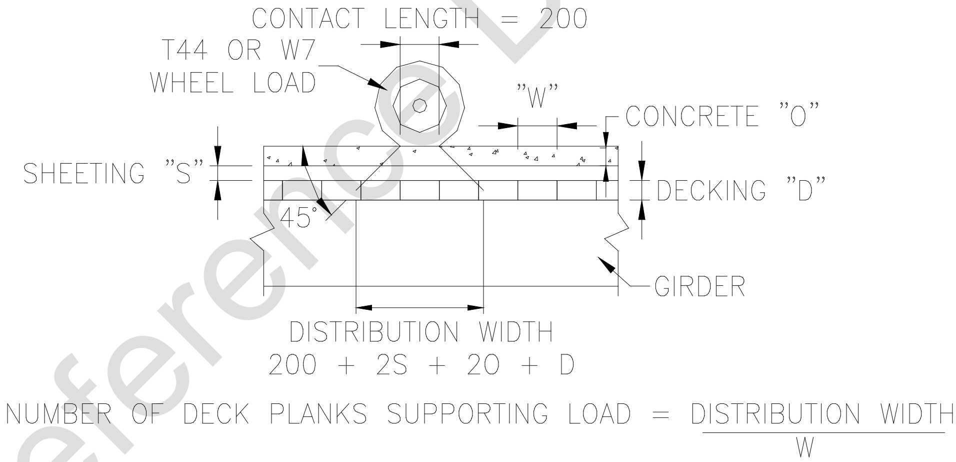

Figure 6.6.4.3-2 Section A-A from Figure 6.6.4.3-1 – Distribution of Wheel Load to Deck Planks

In traditional timber girder bridges, which have only sheeting, the distribution of the wheel along the decking is usually ignored. However, with the increase in the overall depth of the deck due to the concrete overlay, the distribution of the load along the decking would improve significantly. Therefore, the same 45° distribution should also be applied along the direction of the decking as shown in Figure 6.6.4.3-3.

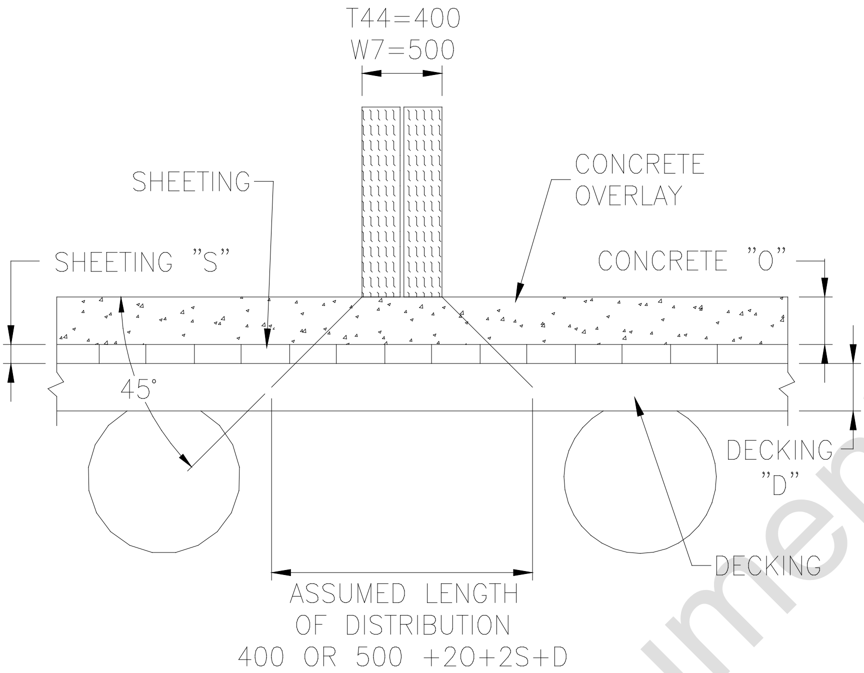

Figure 6.6.4.3-3 Section B-B from Figure 6.6.4.3-1 – Distribution of Wheel Load Along Deck Planks

6. 6.4.4 Load Distribution in Timber Girders

A concrete overlay bridge can be analysed as a grid (or orthotropic plate) similar to traditional timber girder bridges. However, the traditional bridges must be modelled carefully as they generally do not display two-way continuity due to loosening of the bolts connecting the components together. In this regard, the concrete overlay provides improved continuity compared to the traditional timber girder bridge, and thus, a concrete overlay bridge can be more accurately modelled using grid analogies.

6. 6.5 Traffic Barriers

Use of a concrete overlay provides an improved structural medium to which structural traffic barrier posts can be attached. Posts should be attached using bolts cast into the concrete.

The posts, attachments and the railing system should be designed to satisfy Austroads design loading (minimum Level 2). Experience has shown that in order to use a standard traffic railing ("w" beam), the post spacing should be around 1 m. Alternatively, a structural railing can be designed to span between the posts similar to that used with stress laminated deck replacements as described in Section 5.

6. 7 DETAILING AND DURABILITY

Section 1 provides some typical details applicable to all timber bridge systems including girder bridges and stringer deck systems. This subsection provides some additional details for concrete overlay bridges.

6. 7.1 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, Section 4 outlines additional details related to existing (traditional) timber girder bridges including:

- Timber selection
- Notches and section changes
- Sizing of girders
- Bolting and alternate attachments
- Preservative and flashing protection

The details in Section 4 are also to be applied to the existing timber components of concrete overlay bridges. This section reviews a number of additional factors specifically applicable to construction of concrete overlays on existing timber bridges. It is assumed that the existing timber has been refurbished to satisfy the requirements in Section 4.

6. 7.2 Construction and Typical Detailing

The basic design/details for a concrete overlay are shown in the bridge design drawings referenced in Subsection 6.10. This section outlines some of the important features of the design details and construction methodology. This information is important to the strength and durability of the completed bridge.

6. 7.2.1 Preparation of the Existing Timber Components

To ensure the strength and durability of the refurbished bridge, it is important that the existing timber components be prepared properly prior to applying the concrete overlay. The most important consideration is detection and replacement of any deteriorated or damaged timber components as it will be difficult, if not impossible, to replace these members in the future. In addition, the existing components should be secured together by retightening existing bolts and adding new bolts where necessary.

The following identifies some of the steps which should be taken to prepare the existing timber bridge:

- Perform a detailed inspection, including boring of primary members

- Replace deteriorated timber components
- Where termites are discovered, treatment by experienced personnel should be applied to prevent reinfestation. This should be followed up with inspection and retreatment at 6 and 12 months
- Remove sheeting where indicated
- Minimise the use of green timber for replacement components (reuse sound sheeting where it is removed as part of the work or acquire seasoned components from other sources)
- Green timber should be distributed throughout the bridge
- Where large areas are repaired using green timber, pouring of the concrete overlay should be delayed for 6-12 months
- Apply preservative treatment between all interfaces, and on the ends of all timber components being installed, as well as the accessible areas of the existing components
- Carry out a level survey of the top of the deck at the piers and in the middle of each span (minimum 3 points across the deck width at each location)
- Evaluate the levels and adjust bearings/supports to achieve a reasonably level structure which will result in a uniform concrete overlay thickness within +/- 15% of the values specified on the drawings
- Tighten all existing bolts in the decking system which are not being removed and install new bolts where necessary
- Install tie down bolts/coach screws for the overlay as shown on the drawings assuring they project into the concrete overlay with adequate cover (see Subsection 6.7.2.3)
- Seal any large gaps in the decking with galvanised sheeting or hessian to assure retention of the concrete during the pour (a covering of hessian over the entire deck area should preferably be used)
- Install minimum flashing as follows:
    - over the tops and sides of the edge girders
    - top and outside edge of the decking along the sides of the bridge (kerb area) extending at least 300 mm onto deck
    - top, end and sides of the girders and other components at abutments
- Preservative treatment should be applied under all flashing prior to installation

6. 7.2.2 Formwork

The existing timber deck is used as the bottom layer of formwork and should be properly prepared, as outlined in the previous section.

Steel channels or angles, with the flanges facing into the deck, should be used along the sides of the deck, even where traditional timber railing is still to be used. These steel components should have studs welded at mid-depth anchoring them into the concrete overlay consisting of at least M10 x 100mm long at 500 mm spacing. Alternatively, they may be anchored as part of the traffic post connection as shown in the sample drawings referenced in Subsection 6.10. These steel edges provide a solid and smooth screed line.

A steel end protection angle, with one leg projecting into the deck and flush with the finished concrete surface, should be installed at the abutments. An example, including anchorage stud details, is shown in the sample drawings referenced in Subsection 6.10. The protection angles provide a durable end face and can facilitate use of an open end joint where the abutment is modified to improve its durability, as outlined in Section 2.

6. 7.2.3 Reinforcement and Tie Down

The drawings should specify the reinforcement type and placement including tie down details. Minimum reinforcement and tie downs shall be as given in the sample drawings referenced in Subsection 6.10. The following additional points shall also be noted:

- Main reinforcement shall generally be at mid-depth or slightly lower (never above mid-depth)
- Mesh reinforcement shall be lapped as it creates difficulty with concrete cover. Joints shall always be spliced with lap bars
- All coach screws and bolts shall be coated with CN emulsion gel prior to installation in holes
- Where *stage construction* is planned (ie traffic retained on one half of bridge), the following additional points shall be noted:
    - Traffic speed shall be strictly controlled during the pour and curing
    - The timber surface and approaches shall be smooth to reduce dynamic effects
    - Reinforcement shall be securely joined together to prevent movement due to traffic, with particular emphasis on starter bars extending into the driving area
    - It is strongly recommended that all components (timber and reinforcement) in the “pour” area be observed under heavy transient loads to identify excessive movements prior to the pour

6. 7.2.4 Concrete Pour and Curing

Concrete shall have a minimum 28 day compressive strength of 32 Mpa and a maximum slump of 75 mm. However, experience has shown that the use of a maximum water/cement ratio of 0.45 will considerably reduce shrinkage effects. Using a super plasticiser will allow this drier mix to be pumped during the pour.

The concrete should be placed and finished as follows:

- A concrete pump should be used to reach larger areas more readily

- Thorough needle vibration shall be applied initially to assure full compaction
- Care should taken to ensure that the concrete flows under the end protection angles
- A vibrating screed should be used to achieve the final level using a shaped profiler for the 1% crossfall
- Bull floating and a broom finish should be provided with the surface grooves oriented perpendicular to the road
- Moist curing should be adopted (an approved curing agent may be used on low volume roads)
- Apply wet hessian and a plastic cover for a minimum of 48 hours (or 4 days where a high frequency of heavy vehicles is anticipated) before allowing traffic onto the bridge
- On bridges where stage construction is planned, a restriction on traffic speed shall be maintained during the curing period

6. 7.3 Bolting and Alternate Attachments – General

In addition to the typical details shown on the sample drawings referenced in Subsection 6.10, a number of alternate details should be considered to enhance durability and future maintenance.

All bolt holes represent moisture traps and should be preservative treated as outlined in Section 1. However, through holes in the girders should be avoided wherever possible, particularly vertical holes. Some alternate methods of attachment are provided in the subsequent sections.

In addition to avoiding through holes, it is beneficial, for maintenance purposes, that tie downs be detailed to facilitate retightening.

Section 4 also provides a number of alternate details for traditional timber girder bridges which can be applied to concrete overlay bridges.

6. 7.3.1 Attachment of Sheeting

Attachment of longitudinal sheeting represents one of the most difficult challenges with respect to durability, particularly for sheeting directly over the girders. Section 4 outlines several details for the attachment of sheeting on traditional timber girder bridges. These details should also be considered for concrete overlay bridges, where applicable. Installation of the sheeting bolts should be such that they can accessed for retightening in the future.

6. 7.3.2 Attachment of Decking

Since the decking typically runs perpendicular to the girders, there is no need to attach it directly through the girders. Decking should be attached to bolting strips which can, in turn, be attached to cross beams under the girders, or as part of the girder tie down. A number of applicable examples are outlined in Section 4 for traditional timber girder bridges.

6. 7.3.3 Girder Attachment - General

Attachment of girders at supports can require some specially fabricated components in order to avoid holes in the girders. However, the increased durability achieved by avoiding holes through the girders is considered to far outweigh the additional cost. A number of examples are outlined in Section 4 for traditional timber girder bridges and these are also applicable to concrete overlay bridges.

6. 7.3.4 Tie Down and Shear Connectors in Concrete Overlays

Typical tie down and shear connector details are provided in the sample drawings referenced in Subsection 6.10. However, while these details have been field proven, they represent several disadvantages with respect to long term durability, maintenance and repairs including:

- Tie down bolts penetrate through the girders
- Coach screw (shear connectors) cannot be removed in the future preventing component replacements
- Repeated heavy loads can loosen bolts and coach screws by crushing the timber around them. This damage cannot be repaired

The use of coach screws as shear connectors, when embedded directly in the timber girders, cannot be replaced with any other practical detail which would be economical for this type of bridge. Therefore, at this time, coach screws should continue to be used on the understanding that they prevent the removal/replacement of the girders.

However, the tie down of the concrete overlay to the girders can be modified to reduce through holes in the girders. Based on the examples given for traditional timber girder bridges in Section 4, it should be possible to place the tie down bolts adjacent to the girders instead of through the girders.

6. 7.3.5 Flashing Protection

Flashing provides direct moisture protection for timber components and can considerably improve the longevity of timber in exposed conditions. However, it is important that the flashing provide adequate protection against moisture ingress as it will also prevent rapid drying in cases where water has penetrated the flashing.

The timber surfaces under the flashing should be treated with a gel or grease type remedial preservative and lap joints should be effectively sealed to prevent moisture ingress.

6. 8 SPECIFICATIONS

Section 1 lists the relevant specifications applicable to timber bridge construction. These include the applicable Australian Standards, Sections of the Austroads Bridge Design Code as well as the current RTA Construction and Materials Specifications.

6. 9 MATERIAL SUPPLY

Section 1 outlines the basic material supply requirements for timber bridges and Section 4 outlines additional information related specifically to traditional timber girder bridges. Except as noted below, or specified otherwise, the material requirements and specifications outlined in Sections 1 and 4 shall apply as minimum requirements for the timber girders, decking and sheeting. With new designs or major rehabilitation works, it is assumed that design drawings and/or specific construction specifications will be supplied.

6. 9.1 Timber Supply - Member Replacements

All timber girders, corbels and stringers shall always be Durability Class 1. In general, unless otherwise specified, all replacement timber components for existing bridges shall be of equal size and grade. Only hardwood shall be used to replace existing hardwood members.

When possible, only seasoned timber shall be used for the replacement of decking and sheeting. Second hand timber may be used as long as:

- it is completely free of decay and insect attack
- is of comparable durability and grade
- retains at least 90% of its original cross sectional area at any point along its length (to allow for holes and notches)

6. 9.2 Steel Components

Except as noted below, the material requirements and specifications outlined in Sections 1 and 4 shall apply to all steel sections, hardware and reinforcement.

- Reinforcing bars shall be minimum grade 410Y to AS1302
- Reinforcing fabric shall be to AS1304

6. 9.3 Concrete

The concrete shall have a minimum 28 day compressive strength of 32 Mpa and a maximum slump of 75 mm. See additional notes in Subsection 6.7.2.4.

6. 10 REFERENCES

Development of this section has been based primarily on the following references:

1. McPhail, John, “Developments in NSW Concrete Overlays of Timber Bridges”, Paper – Institute of Municipal Engineering Australia (IMEA) Conference Proceedings, Penrith, March, 1993.

2. Marsden, W., “Report on the Performance of the Fibrecrete Overlay on Black Creek Bridge”, BHP, May, 1996.

3. Roads and Traffic Authority NSW, “Bridge Over The Murray River, Oedings Bridge”, Design Drawings Reg Plan No. 0086 104 BC 0105, August, 1994.