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 Some of the contents are out-of-date.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

TIMBER GIRDERS, DECKING AND SHEETING
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4. TIMBER GIRDERS, DECKING AND SHEETING

4.1 GENERAL

4.1.1 Scope

Section 4 covers the design, construction and maintenance of all traditional timber girder bridges including the decking and sheeting and specified components as outlined in Subsection 4.2. It also applies to timber girders including the sheeting, decking and sheeting systems on timber trusses and steel lift span bridges.

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 timber girder deck systems.

4.1.2 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 deck systems 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

4.1.3 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 timber girder deck systems.

*Bolting Strips*

Longitudinal timber components (typically 200 mm x 100 mm) between girders on the underside of the decking used to bolt the decking together (see Figure 4.7.1.8-1)
Corbels
Longitudinal timber bearing members under girders providing support and some continuity between girders in adjacent spans (see Figure 4.7.1.11-1)

Decking
Closely spaced sawn timbers up to 125 mm deep (200 mm to 250 mm wide) supported on girders (see Figure 4.2.1-2)

Flush Seal Wearing Surface
Bitumen spray seal with crushed rock used to seal the timber deck surface and provide traction for vehicles

Girder Bridges
Term referring to structures where the timber girders are the primary elements between supports (see Subsection 4.2)

Girder Deck System
Term referring to a deck structure comprising timber girders, decking and sheeting which form part of a larger superstructure such as in timber trusses (see Subsection 4.2)

Girders
Typically referring to longitudinal bending members (round or rectangular) of fairly large cross section

Sawn (Stringers or Girders)
Girders or stringers which have been sawn to a rectangular cross section

Sheeting
Timber plank running surface, generally 50 mm to 75 mm thick placed parallel to the roadway and supported on timber decking (see Figure 4.2.1-2)

Sizing
A term referring to notching or other material removal to adjust a component to meet specific dimensions

Stress Laminated Timber
Defined in Section 5

Stringers
Typically referring to longitudinal bending members (usually sawn) of relatively small cross section

Timber Concrete Composite
Composite timber girder with a concrete deck as defined in Section 7
Temporary timber props used to support a structure from the ground (see Figure 4.5.3.1-1)

4.2 STRUCTURE TYPES AND COMPONENTS

A review of the more common types and uses of timber girders, decking and sheeting systems 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 4.1.3.

In the following sections, and throughout this section, reference is made to both timber girder bridges and timber girder deck systems. A bridge refers to a structure where the girders are the primary components spanning between the abutments and/or piers (Subsections 4.2.1 and 4.2.2). A deck system refers to a superstructure where the girders form part of a larger structure (Subsection 4.2.3).

4.2.1 Traditional Timber Girder Bridges

A traditional timber girder bridge is shown in Figures 4.2.1-1 and 4.2.1-2. The majority of timber girder bridges include round timber girders, transverse timber decking and longitudinal timber sheeting.

Figure 4.2.1-1 Typical Round Timber Girder Bridge - Wakool River
The traditional (original) bridges also incorporated timber kerbs, posts and rails as shown in these figures.

Typically, these bridges are supported by timber substructures as discussed in Section 2 and shown in Figure 4.2.1-3. At the piers, the girders in opposing spans are usually butted and provided with timber corbels as shown in the figure. These corbels provide improved bearing support and some limited continuity.

Timber sheeting is usually provided with a flush seal wearing surface as shown in Figure 4.2.1-4. to provide traction for vehicles as well as to protect the sheeting from wear and excessive moisture changes.
It should be noted that while longitudinal sheeting is referred to as forming part of a traditional system, many original designs did not include such sheeting. Even some existing bridges only use transverse decking as shown in Figure 4.2.1-5. However, over the past 30 years, the majority of bridges have been provided with sheeting which improves both strength and durability.

4. 2.2 Sawn Timber Girder Bridges

While less common, there are a number of timber girder bridges which use sawn timbers. An example is shown in Figure 4.2.2-1 where both the girders and corbels are composed of sawn rectangular sections.
Sawn girders are not uncommon but are generally only used for deck systems in larger structures, as will be outlined in the next section. However, except for the sawn girders, all of the points outlined in the previous section also apply to these bridges.

4. 2.3 Timber Girder (and Stringer) Deck Systems

Timber girders, decking and sheeting are also commonly used as deck systems on larger timber structures such as trusses. In these cases, the main timbers are usually referred to as *stringers* which span between cross girders as shown in Figure 4.2.3-1.

[Figure 4.2.3-1 Timber Girder Deck System - Wakool River Bridge]

Also quite common is the use of the same type of timber girder deck system on larger steel structures, particularly steel lift spans as shown in Figure 4.2.3-2.
Figure 4.2.3-2  Timber Girder Deck on Steel - Swan Hill Lift Span

In nearly all of these cases, the majority of timber girders are of sawn cross section although it is not uncommon to find some round sections which have been introduced during replacement.

4. 2.4 Timber Decking and Sheeting

There are some deck systems which support only decking and sheeting with no longitudinal timber girders. These include the PWD and McDonald trusses (discussed in Section 3) which have closely spaced timber cross girders. On these bridges, the decking is oriented diagonally (45°) and the sheeting longitudinally.

In addition, there are some steel structures with longitudinal steel girders which also support only timber decking and sheeting as shown in Figure 4.2.4-1.
4. 3 INSPECTION PROCEDURES

Section 1 outlines the basic inspection procedures for all timber bridge types and these procedures apply to the timber girders, decking and sheeting on all bridge types. This subsection highlights these specific additional considerations for timber girders, decking and sheeting.

4. 3.1 Objectives and General Requirements

The basic objectives and requirements outlined in Section 1 must be considered during the inspection of timber girders, decking and sheeting.

4. 3.2 Inspection Records

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

4. 3.3 Annual Visual Inspection

Annual visual inspections should be carried out on all timber girders, decking and sheeting and should be done together with the annual maintenance as outlined in Section 1.
4. 3.3.1 Deck Profile

The overall level of the deck should be observed to detect any obvious sagging in the girders which could indicate deterioration of the girders or stringers. However, in timber truss bridges, an uneven deck can also be caused by problems with the truss, as outlined in Section 3, or by movements in the substructure.

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

4. 3.3.2 Inspection Under Transient Loading

The basic requirements for inspection under transient loads are outlined in Section 1.

The following specific deck areas, shall be observed for excessive movements and other considerations as noted:

- overall vertical displacement of the girders and the deck between supporting members with particular emphasis on differentials between the girders (i.e., one moving more or differently than others)
- apparent lateral or longitudinal movement of the deck
- local movements of the sheeting or decking indicating loose components
- movements at other connection details, particularly at the girder or stringer supports and corbels
- inconsistency of local deck movement under the moving wheel (apparent local deformation around the wheel should be uniform along the span)
- signs of structural damage or deterioration which may be exposed during movements
- movements at previously reported problem areas
- movements at previously repaired areas

4. 3.3.3 Structural Defects and Damage

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

- member fractures due to loading, with particular 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 girders
  - bearing between girders and corbels
  - top of girders supporting decking
- evidence of loose connections and/or enlarged holes around bolts
- evidence of vehicle damage to railings and kerbs
- excessive sag in girders or decking

One of the most typical forms of structural damage to timber girders is shown in Figure 4.3.3.3-1. This is caused by abrupt changes in section and details of proper tapers for section changes are outlined in Subsection 4.7.

![Figure 4.3.3.3-1 Typical Splitting of Girders at Supports](image)

4.3.3.4 Timber Deterioration

All girders, decking and sheeting shall be inspected for 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 kerbs
  - holes at connections
- under flashing and behind other protective coatings
- ends of the deck system at abutments, with particular emphasis on the contact areas with the backfill

Some critical areas for deterioration in girders are shown in Figure 4.3.3.4-1. The tops of the girders can develop deterioration at any location. The centre of the girders generally develop deterioration starting at the ends.
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.

A typical example of deterioration in the heart of a timber girder is shown in Figure 4.3.3.4-2 where the girder has been cut in half. Note also the deterioration at the top of the decking in contact with the sheeting.

Figure 4.3.3.4-2  Typical Deterioration at Heart of Timber Girder

Figure 4.3.3.4-3 shows another example of deterioration at the top of a girder in contact with the decking which extends into the heart of the member.
4. 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:
  - under flashing
  - between timber interfaces
  - around bolts
- boring of main structural components including all girders and stringers

4. 3.4.1 Timber Boring

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

- all timber girders and stringers at their ends (where the end is not exposed for visual inspection) as shown in Figure 4.3.3.4-1
- 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

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 and stringers over supports, it is preferred that the vertical holes be inclined to reach over the support as shown in Figure 4.3.3.4-1. 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. Random checks should be performed adjacent to bolts and near ends which are not exposed.

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

4.4 MAINTENANCE

Section 1 outlines the basic maintenance procedures for all timber bridge types and these also apply to timber girder bridges. This subsection highlights specific additional considerations for timber girders, decking and sheeting.

4.4.1 Objectives and General Requirements

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

4.4.2 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 4.7 reviews a number of considerations specifically applicable to timber girders, decking and sheeting.
4. 4.3 Annual Maintenance

Routine maintenance should be carried annually on all timber girder bridges and deck systems as outlined in Section 1. This subsection reviews a number of considerations specifically applicable to timber girders, decking and sheeting.

Routine maintenance should include:

- removal of fire hazards, with emphasis on grass and bush, 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 attachment of the girders and corbels
- retighten deck and sheeting bolts where movement is observed
- spot checks should be carried out on less accessible bolts to determine if further work is required
- preservative protection should be reapplied where possible and spot checks should be carried out on covered components to see if further work is needed
- minor collision damage to railing systems should be repaired. Major damage should be reported and remedial repairs carried out if possible

4. 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 timber girders, decking and sheeting:

- retightening of all bolted connections including attachment of the deck and sheeting
- 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 sheeting components should be replaced
- a bitumen seal should be applied to any exposed top areas of timber sheeting

4. 4.5 Treatment of Fungal and Insect Attack

The general requirements outlined in Section 1 should be applied to timber girders, decking and sheeting and any fungal and insect infestation must be treated. A specialist should be engaged if termite 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.

4. 5 REHABILITATION AND REPAIRS

Section 1 outlines the general aspects of rehabilitation and repairs to timber bridges. This subsection discusses repairs and rehabilitation related specifically to timber girder bridges, deck systems and their components. Each typical component type is dealt with in terms of both temporary (emergency) repair and 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.

4. 5.1 Sheeting

Damage to timber sheeting does not usually represent a serious situation unless the supporting decking is also damaged. The following outlines typical methods of repair and replacement based primarily on traditional details. It should be noted that additional optional details for installing sheeting (and decking) are provided in Subsection 4.7. These are intended to enhance durability.

4. 5.1.1 Temporary Repairs to Timber Sheeting

Temporary repairs can be carried out from the top of the deck. Replacement sheeting should be full length and may be attached using coach screws as long as the decking is sound. Minimum M16 coach screws shall be used with large series washers and placed as shown in Figure 4.5.1.1-1. Butt joints should be offset by at least 500 from those in adjacent members.

![Figure 4.5.1.1-1 Temporary Attachment of Sheeting](image-url)
Coach screws shall be installed by preboring for the root of the thread and shank of the screw, and shall be turned into place using a wrench (not driven).

These repairs should be monitored every few days until replacement sheeting can be installed using M16 bolts through the decking.

4. 5.1.2 Replacement of Sheeting - General

Replacement of large areas of sheeting may be carried out under traffic, if the roadway width permits. Replacement of the entire sheeting layer should consider the optional details outlined in Subsection 4.7.

The typical attachment of sheeting shall use M16 bolts with 50 mm x 50 mm x 5 mm washers on top and timber lock washers at the bottom. Two bolts shall be used at the end of each component with single bolts along the component at a spacing of not more than 1500 mm on a staggered pattern as shown in Figure 4.5.1.2-1. Where the sheeting falls directly above a girder, only a single bolt at the ends should be used passing through the girder. An optional detail for butt joints over a girder is provided in Subsection 4.7.

Butt joints in sheeting should be avoided over pier supports and corbels, wherever possible, in order to minimise holes in the ends of girders and corbels as well as through capwales and headstocks.

4. 5.1.3 Replacement of Small Areas of Sheeting Under Traffic

The general procedure for sheeting replacement under traffic shall be as follows:
- full length replacement should be performed where possible (short lengths may be replaced where full sheeting replacement is scheduled within several months)
• remove bitumen surfacing around the bolts to be removed
• cut off heads of bolts (one plank at a time) and remove washers
• pry up the plank gradually along its length to loosen the bolt and facilitate drifting of the bolt (do not remove sheeting)
• drift out all bolts where possible
• properly size the new sheeting and mark approximate locations of old holes in decking
• remove old component and remove any additional obstructions (particularly where bolts could not be drifted out previously)
• coat the top of the existing decking and the underside of the new sheeting with a gel or grease type remedial preservative and install
• fix new sheeting using new holes (not existing holes) with M16 bolts as previously specified in Subsection 4.5.1.2
• apply wearing surface to new sheeting immediately after installation
  • small areas may be sealed with emulsified bitumen
  • large areas should have a flush seal or an alternate seal with crushed rock to provide traction
  • planks should not be left unprotected

4. 5.1.4 Replacement of Large Areas or Full Sheeting Under Traffic

Generally, if more than 30% to 40% of the sheeting requires replacement, all of the sheeting should be replaced. All decking should also be considered for replacement at the same time, as outlined in Subsection 4.5.1.5.

The general procedure for large areas or full sheeting replacement under traffic shall be as follows:

• full length replacement of components shall always be carried out and butt joints staggered in adjacent planks by at least 500 mm
• depending on the width of the bridge, the work may be carried out in stages if the traffic can be moved to different alignments (a specific procedure should be planned)
• for a specific stage (area of sheeting to be removed), mark out on the deck surface the wheel track areas for the traffic lane (it is intended that these areas be retained until the last moment to carry traffic)
  Note: in some cases it may be possible to align heavy traffic specifically over girders (this must be assured). In this case, it may be possible to remove all sheeting and allow the traffic to drive directly on the decking at slow speeds
• strip old sheeting, except in wheel track areas (only as much area should be stripped as can be completed in the same day)
• drift old bolts out of decking where possible
• coat the top of the existing decking and the underside of the new sheeting with a gel or grease type remedial preservative and install
• fix new sheeting using new holes (not existing holes) with M16 bolts as previously specified in Subsection 4.5.1.2
• when the new sheeting is completed, it should be sealed immediately with a new flush seal surface
4. 5.1.5 Replacement of Sheeting and Decking Under Traffic

The general procedure for full sheeting and decking replacement under traffic shall be as follows:

- the length of sheeting and decking replacement shall always be maximised
- butt joints in the sheeting shall be staggered in adjacent planks by at least 500 mm
- butt joints in the decking shall always be above a girder and shall be staggered in adjacent planks above alternate girders
- depending on the width of the bridge, the work may be carried out in stages if the traffic can be moved to different alignments (a specific procedure should be planned)
- for a specific stage (area of sheeting to be removed), mark out on the deck surface the wheel track areas for the traffic lane (it is intended that these areas be retained until the last moment to carry traffic)
  
  **Note:** in some cases it may be possible to align heavy traffic specifically over girders (this must be assured). In this case, it may be possible to remove all sheeting and allow the traffic to drive directly on the decking at slow speeds
- strip old sheeting, except in wheel track areas (only as much area should be stripped as can be completed in the same day)
- select length of decking (plus sheeting) to be replaced at one time (typically about 1.5 m along the bridge)
- cut through remaining sheeting with chain saws at each end of the section to be removed
- within the length of decking to be removed (ie: 1.5 m), remove the heads of bolts which pass through the girders (and bolting strips if installed) and raise the decking (by wedging or jacking) to allow cutting of the bolts at the girder/decking interface (see Figure 4.5.2.2-1)
- cut the sheeting and decking in sections and first remove all sections outside the wheel track area
- drift any accessible bolts out of the girders and apply a gel or grease type remedial preservative to the tops of the exposed girders
- fit flashing, if an alternate attachment method is to be used, as outlined in Subsection 4. 7.1.13
- new decking should be presized and the sides treated with a gel or grease type remedial preservative
- close the bridge to traffic and remove the final sections of decking
- quickly treat the remaining areas of the tops of the existing girders and lay down new decking
- traffic may be allowed at slow speeds over the new decking if heavy vehicles can be directed over the girders. Alternatively, preconstructed timber mats made of old planks can be laid down over the length of the opening as shown in Figure 4.5.1.5-1
- secure decking to new timber bolting strips and treat tops with a gel or grease type remedial preservative before installing sheeting
install new sheeting where possible to obtain required butt joint stagger
in track (traffic) areas, it may be necessary to continually provide temporary short lengths to maintain a full surface
bolt new sheeting and decking together using M16 bolts as previously specified in Subsection 4.5.1.2
each decking component should have at least three bolts connecting it to either the sheeting or to the bolting strips
when the new sheeting is completed, it should be sealed immediately with a new flush seal surface
temporary lengths of sheeting may be used to fill in staggered sections of sheeting overnight.

Figure 4.5.1.5-1 Temporary Timber Running Mat

The bridge should not be left unattended while the decking is not fully secured and full sheeting is not provided in the traffic area. The bridge should not be left overnight without full sheeting, unless the traffic can be properly restricted to a fully sheeted area.

4. 5.1.6 Strengthening and Upgrading

Traditionally, most sheeting has been 50 mm thick and runs longitudinally (parallel to the roadway). On bridges with high traffic volumes, the sheeting generally deteriorates due to wear and fatigue not decay. Major repairs and maintenance can be required every two to three years with minor repairs annually. In most cases, it has been found that 75 mm thick sheeting has proved to be more robust and durable, requiring less maintenance, with a life cycle of up to 5 to 6 years or more, even under high traffic volumes.
Alternate orientation of the sheeting as proposed in Subsection 4.7.1.7.3 should be considered to avoid holes in the girders.

4. 5.2 Timber Decking

Except in a few cases, as noted below, timber decking runs perpendicular to the roadway. Traditionally, decking utilised 125 mm deep planks, particularly on structures where sheeting was not specified. However, with the addition of sheeting, it has been found that 100 mm decking can be maintained in most cases, particularly when combined with 75 mm thick sheeting. However, the capacity of the sheeting should be properly evaluated before any thinner material is used.

In the case of the PWD and McDonald trusses, the decking is supported on closely spaced transverse timber beams and so it is not feasible to run the decking transverse to the roadway. On these bridges, the decking is oriented diagonally (usually at 45° to the roadway).

4. 5.2.1 Temporary Repairs

Generally, damaged or deteriorated decking usually shows itself only when several adjacent planks, and the overlying sheeting, are also weakened and failing.

However, in cases where small sections of deteriorated decking is discovered, it can usually be left in place until proper replacement, as described in the next section, can be arranged as long as the sheeting is sound and not showing signs of distress.

Where deteriorated decking is reflected by distress in the overlying sheeting, or where a potential failure under heavy loads is apparent, it may be temporarily repaired as shown in Figures 4.5.2.1-1 and 4.5.2.1-2.
The decking should be cut to maximum length between the girders for a tight fit. Continuous blocking should be used to attach the temporary decking together and also to at least two of the existing adjacent decking planks. 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 coach screws should be dipped in a preservative solution and used to plug the holes in the girders after use.

**Figure 4.5.2.1-1** Plan of Temporary Decking Repair

**Figure 4.5.2.1-2** Section for 4.5.2.1-1
This type of temporary repair should be monitored, at least twice a week, until the decking can be properly replaced.

4. 5.2.2 Replacement of Single or Groups of Decking Under Traffic

The following is the general procedure for the replacement of individual (or small groups of) decking without removing the sheeting:

- maximum lengths of decking plank should be replaced where possible (short lengths may be replaced where full deck replacement is scheduled in the near future)
- remove bitumen surface around areas where bolts are to be removed and new bolts are to be installed
- cut heads of bolts attaching existing deck plank and drift out bolts wherever possible
- bolts which pass through the girder should be severed between the girder and the decking as shown in Figure 4.5.2.2-1
- old decking may be cut into smaller lengths to facilitate removal
- only one deck plank at a location shall be removed at a time if the work is carried out under traffic
- check for clearances across the full length of the space for the new plank and remove any obstructions
- the new plank should be of the same cross section (and age, if possible) to ensure a tight fit
- the use of very fresh (green) material should be avoided for the replacement of individual components as they will shrink and loosen
- coat the new deck plank with a gel or grease type remedial preservative before installation
- slide new deck plank into place and fix using M16 bolts with a 50 mm x 50 mm x 5 mm washer on top and timber locking washer on the bottom
- the new plank should be secured with at least three bolts connecting it to either the sheeting or the bolting strips
- apply bitumen wearing surface to the top of the sheeting above the repair area
4. 5.2.3 Replacement of Full Decking and Sheeting Under Traffic

Replacement of all decking and sheeting under traffic should be carried out as outlined in Subsection 4.5.1.5.

4. 5.2.4 Strengthening and Upgrading

Generally, except for increasing the thickness of the decking and sheeting, there are no effective methods which will improve the integrity of a traditional timber sheeting and decking system. Bridges which carry heavy loads and large traffic volumes should be maintained more frequently than every 12 months. Durability can be improved by retightening bolts on a semi-annual basis, particularly after new (green) components have been installed.

4. 5.3 Timber Girders and Stringers

Although the following information is directed towards the traditional round timber girder bridges, it is also applicable to square timbers and the stringers used in larger structures.

4. 5.3.1 Temporary Repairs Using Props (Toms)

Temporary repairs for damaged girders in traditional girder bridges 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 shown in Figure 4.5.3.1-1. All components shall be securely attached to each other and the girders to prevent movement (steel angle brackets and coach screws should be used). A single post may be used for heights up to...
3 m. Over 3 m, an additional post should be placed under adjacent girders and the posts should be braced to each other. This method should not be used for heights over 4 m, or in poor ground conditions, unless an engineering drawing is provided.

This temporary repair should be monitored daily until the replacement girder is installed. 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 other components.

Figure 4.5.3.1-1  Temporary Tom Under Girder

4. 5.3.2 Temporary Additional Girders

As a temporary measure, an additional girder can be installed directly adjacent to the damaged member using the following general procedure:

- size the temporary girder to suit the support conditions and span length
- in single span bridges, or other decks with no corbels, one end of the girder may require a slight reduction in depth to allow it to slip over the support (capwales or headstock)
- the girder should lowered over the side of the bridge and brought under the span using cables threaded through the deck as shown in Figure 4.5.3.2-1
- the girder is lifted into place and blocked up into position as close to the damaged girder as possible, as shown in the figure
• as this is only a temporary measure, the girder should be attached to the
decking only enough to keep it in place and in a manner which can easily be
removed to facilitate final replacement

While this additional girder will provide temporary support, it should not be
considered a long term solution as this girder 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 shown in
Figure 4.5.3.2-1. While replacement of the girder can be carried out as outlined
in the next section, an alternative may be to add another girder on the other
side of the damaged girder which will relieve the overstress in the adjacent
girder.
Figure 4.5.3.2-1  Positioning Temporary Girder Under span
4. 5.3.3 Girder Replacement

Replacement of the damaged girder would basically be carried forward from the method outlined in the previous section as long as the temporary girder was properly selected to meet the required grade and size.

With the girder in place beside the damaged girder, replacement can be carried out using the following general procedure:

- remove bitumen surface around the area where bolts are to be removed and new bolts are to be installed
- cut heads of bolts attaching existing deck planks and drift out bolts wherever possible
- bolts which cannot be drifted out should be severed between the girder and the decking as shown previously in Figure 4.5.2.2-1
- the use of wedges may be necessary to sever bolts between the girder and the corbel at the support
- using a combination of jacks, as shown in Figure 4.5.3.3-1, the new girder can be used to push the old girder out while the new girder is moved into place
- the new girder should be secured to the decking and corbel (alternate methods of attachment are outlined in Subsection 4.7)
- no heavy traffic should be allowed above the replacement area while work is in progress

![Figure 4.5.3.3-1 Positioning New Timber Girder](image_url)

4. 5.3.4 Strengthening and Upgrading

There are two practical methods of strengthening and upgrading existing timber girder bridges and deck systems using the same general design style. The size of the girders can be increased or additional girders added. In most cases, obtaining larger girders is becoming more difficult and, in most instances, the available girders are actually getting smaller.
In a bridge where the existing girders are sound, additional girders should be added between the existing members. However, although smaller girders may be used, it is important that a proper engineering evaluation be performed. Girders of smaller cross section will carry a smaller portion of the load related to their stiffness.

If the existing girders are in poor condition and are to be replaced, it is generally more practical to relocate the new replacement girders to provide more girders at a smaller spacing. Again, it is important that a proper engineering evaluation be carried out.

4. 5.4 Life Expectancy of Timber Girder Bridges

Timber girder bridge and deck systems, with decking and sheeting, rate as one of the highest maintenance bridge systems. The layered timber sheeting and decking create extensive timber interfaces between components which trap moisture and which cannot be accessed easily for inspection and treatment. When combined with the numerous bolt holes through the decking, sheeting and girders, the components are placed in a very high risk environment for decay and insect attack. (Some alternate details are discussed in Subsection 4.7)

In addition, the performance of the systems is highly dependent on the bolting of the components. Through shrinkage, the components are continually subjected to loose connections. On bridges with high volumes of traffic, the effects are amplified as the repeated loads begin to enlarge bolt holes as the components move independently.

As a result, except for bridges subjected to heavy traffic, the life expectancy of components is usually limited by the potential for decay and/or insect attack. In general terms, the average life expectancy for decking and sheeting can be 8 to 10 years, depending on the environment. Under heavy traffic, life expectancy can be as low as 4 to 6 years through a combination of fatigue and deterioration.

Timber girders are generally of higher durability and, on low traffic volume roads, can reach an average life expectancy of up to 20 to 30 years, depending on the environment. However, on high traffic volume roads, the continual replacement of decking and sheeting creates additional damage to the girders as numerous additional holes are introduced. Life expectancy in these situations can be as low as 10 to 15 years.

In summary, it is important to consider alternative designs in the cases where the existing system requires continued extensive maintenance. Some options are outlined in the next section. In addition, it is very important to consider some of the alternative details to enhance durability as outlined in Subsection 4.7.
4. 5.5 Replacement Options for Timber Girder Bridges and Decks

There is a trend to replace many timber girder bridges and timber stringer deck systems, particularly on high traffic volume roads, with alternate designs.

One of the available options to replace timber girder bridges for spans of 8 m and over is to use the timber concrete composite (TCC) system, detailed in Section 7. With the TCC system, there is usually a slight increase in dead load over the existing system. However, the existing foundations can usually be retained. These TCC bridges are strong and are not susceptible to the effects of repeated heavy loads. With proper maintenance, they should have a life expectancy of at least 30 to 40 years depending on the environment and the durability of the timber girders.

For girder bridges and stringer deck systems of spans less than 8 m, the stress laminated timber (SLT) deck system, detailed in Section 5, has been used many times. The SLT deck system generally represents a reduction in overall dead load as the deck replaces the stringers, decking and sheeting. These new decks are detailed to be completely waterproof so that the timber is kept dry. As well, the details are such that they are reasonably well protected against insect attack and can be easily inspected and maintained. With proper maintenance and inspection, the anticipated life expectancy of a SLT deck is currently expected to exceed 50 years depending on the environment and the durability of the timber.

An additional benefit of both of these options is that they can be installed with minimum road closures as they can be preassembled in modules as described in the relevant sections.

4. 6 ENGINEERING EVALUATION

Section 1 outlined the basic requirements for the engineering design and evaluation of timber bridges. This subsection highlights a number of considerations directly related to timber girders, decking and sheeting.

4. 6.1 Design Specifications

Design of timber girder bridges and deck system components shall satisfy 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 Section 1.

4. 6.2 Timber Capacities

Basic determination of timber capacities using AS1720 is outlined in Section 1 and, except as noted below, shall be applied to the design of timber girders, decking and sheeting.
4. 6.2.1 Duration of Load Factor $k_1$

Generally, for the design of timber elements in girder and stringer bridges not subjected to earth pressure, water flow or high dead load forces, the duration of load factors specified in Section 1 for the live plus dead load combination are usually applicable. However, flood loading may require consideration in some situations.

4. 6.2.2 Strength Sharing Factor $k_9$

The modification factor for strength sharing is applicable to both the sheeting and decking components. Depending on the component spacing and span length, it may also apply to timber girders and stringers. In all three cases, the strength sharing systems are considered as discrete parallel systems as defined in AS1720. Even though the decking is joined through the sheeting, the components are not specifically connected to each other.

The number of components assumed to be in the strength sharing system for each component type will depend upon the load distribution assumptions as will be discussed in the next section.

4. 6.3 Load Distribution for Girders, Decking and Sheet ing

Load distribution to the elements in timber girder bridges and stringer deck systems is usually based on simple assumptions. However, the following guidelines are based on the assumption that the structure has been properly maintained and the component connections are reasonably tight.

4. 6.3.1 Load Distribution to Sheet ing

Basically, it is assumed that only those sheeting elements in contact with the design wheel (tyre) load will share the load. This will depend upon the following variables:

- design load under consideration (ie T44 or W7)
- orientation of the sheeting (usually longitudinal, sometimes transverse or diagonal)
- width of the sheeting

However, unless the sheeting is supported on decking planks which are spaced apart, which is unusual in NSW, the sheeting components are not considered to be elements which require specific design calculations.
4. 6.3.2 Load Distribution and Assumed Span Length for Decking

Two situations are to be considered when determining the load distribution to decking components: decks without sheeting and decks with overlying sheeting.

For decks which do not have any sheeting, only those components directly in contact with the design wheel (tyre) load will share the load. This will depend upon the following variables:

- design load under consideration (ie T44 or W7)
- orientation of the decking (usually transverse, sometimes diagonal)
- width of the decking

Typical decking is transverse and usually wider than 200 mm. In this case, the wheel contact length of 200 mm will be carried by only one deck plank as shown in Figure 4.6.3.2-1. The span of the decking should be taken as the clear distance between the supports and assumed to be simply supported as shown in the figure. Although physically the decking is continuous over the girders, it will rarely act as a continuous member unless all the bolts across the deck (for all the decking) are very tight at all times. The latter is impractical, rarely achieved and never maintained. The conservatism introduced by assuming a simply supported span is offset slightly by assuming the span is the clear distance between support bearings. As a “rule of thumb”, the bearing width on top of a round girder should be taken as 200 mm.

![Figure 4.6.3.2-1 Load on Decking Without Sheeting](image)

Where the decking is overlayed with sheeting, some additional distribution of the load can be assumed to take place. In this case, 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 the sheeting
- width and depth of the decking
Most typical decking is transverse and the sheeting is longitudinal. As a simple method of distribution, the load can be assumed to disperse through the sheeting and decking at a 45° angle as shown in Figures 4.6.3.2-2 and 4.6.3.2-3. In this case, the width of the load distribution would be a function of the sheeting and decking depths as shown in the figures.

As an example, with 75 mm sheeting and 100 mm decking, the assumed distribution width for the deck in the figures would be 450 mm. The number of planks mutually supporting the load would be 450/200 = 2.25. Therefore, the design load would be divided by 2.25 to determine the load carried by one plank and the strength sharing factor would be based on 2.25 components using the formula in AS1720. Again, the span of decking should be taken as the clear distance between supports and assumed to be simply supported.

![Figure 4.6.3.2-2 Load on Decking With Sheeting](image)
4. 6.3.3 Load Distribution in Timber Girders

While it is possible to analyse a timber girder and decking system as a grid (or orthotropic plate), this would assume that the deck is a two-way continuous structure. Again, it is difficult to keep the connections in these bridges tight at all times. Therefore, a grid analysis could provide a non-conservative result and must only be applied with care.

4. 7 DETAILING AND DURABILITY

Section 1 provides some typical details applying to all timber bridge systems, including girder bridges and stringer deck systems. This subsection provides some additional details for timber girders, decking and sheeting.

4. 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, this section reviews a number of factors specifically applicable to timber girders, decking and sheeting.
4. 7.1.1 Timber Selection

All timber girders and stringers should be selected to provide the highest durability as they are expected to provide a longer service life than the decking and sheeting. 

As discussed in Subsection 4.5.4, girder bridges and deck systems with decking and sheeting represent a high maintenance combination. While it is difficult to prevent the high moisture conditions that occur between the components, durability can be enhanced by applying some alternate detailing with particular emphasis on reducing or eliminating holes in girders and stringers.

4. 7.1.2 Construction Detailing

Proper construction detailing must be provided in order to avoid unnecessary water traps and stress concentrations. In line with the considerations outlined in Section 1, the following areas should be given specific attention in timber girder and stringer systems:

- avoiding unnecessary notches in new timber components, with particular emphasis on abrupt changes in section
- avoid drilling through girders and stringers and other components by providing alternate attachments
- apply a gel or grease type remedial preservative protection between all contact surfaces, particularly the decking and sheeting as well as the tops of girders and stringers
- apply preservative to all bolt holes during assembly
- avoid flashing where holes will be drilled through a member

The following subsections provide a number of specific details that should be considered.

4. 7.1.3 Notches and Section Changes - General

Care should be taken when providing section changes in timber girders and other components to avoid stress concentrations and to allow access for inspection and treatment.

In general, the ends of round girders which require section changes should be tapered using a 1 in 5 slope as shown Figure 4.7.1.3-1. The taper should begin at least 20 mm away from any contact or bearing surface as shown in the figure.
In addition, it is particularly important not to reduce the depth of the girder by more than 25% and to limit the depth of the notch at the bearing. Some proposed limits and details are provided in the next section.

The example shown in Figure 4.7.1.3-2 is of a timber girder (recently installed) where its depth at the support is only about 50% of the original diameter. The huge notch at the bottom (even with the correct taper) represents a large stress concentration with a high potential for longitudinal splitting. As an example, the splitting shown in Figure 4.7.1.3-3 was precipitated by a section change even smaller than that shown in Figure 4.7.1.3-1.

**Figure 4.7.1.3-1**  Sizing Round Timber Girders - General

**Figure 4.7.1.3-2**  Excessive Reduction in Girder Depth
In addition to an increased potential for splitting, the removal of this much material has significantly reduced the member strength unnecessarily. The timber support under the girder, as shown in Figure 4.7.1.3-2, could easily have been lowered by sizing the timber bearing instead of the girder.

In cases where all new timber girders are to be installed, the larger diameter ends should all be placed at the same support. As well, the support level should be chosen to suit the largest diameter possible and spacer blocks should be used under the girder bearings. This will allow proper adjustment of the bearing level for future girder replacements and avoid large section changes at the ends of the girders. Some examples of bearing attachment are outlined in Subsection 4.7.1.6.

### 4. 7.1.4 Preferred Sizing for New Round Timber Girders

In general, the sizing of round timber girders, as shown in Figure 4.7.1.4-1, should satisfy the following limits:

- finished depth at support not less than 80% of diameter
- maximum depth of (bottom) notch “B” = 15% of diameter
- minimum flat width at the bearing of 50% of the diameter
- minimum flat width along the top of the girder of 150 mm

The above are preferred limits where the minimum finished depth has been derived in concert with the limits placed on the maximum notch (B) at the support. These two conditions will minimise the potential for splitting as well as ensuring that the strength of the girder is properly utilised.

The minimum 150 mm flat width on the top of the girder is to provide an adequate bearing for the timber decking. The actual depth of the material to be removed “T” should be selected to allow for variations in diameter and alignment along the girder.
However, the limit on “B" is only practical under certain conditions, particularly for existing bridges. In most existing bridges the required depth of the girders at the support is fixed and usually ranges between 300 mm and 350 mm. A typical set-up for a common design using girders with end diameters ranging from 350 mm to 450 mm is shown in Figure 4.7.1.4-2. This is, in fact, the most common size used in past designs.

![Preferred Limits for Round Girder Sizing](image1)

**Figure 4.7.1.4-1  Preferred Limits for Round Girder Sizing**

However, problems occur when larger diameter girders are provided than those required, whether for a new design or as replacements in an existing bridge. If the support elevation has been set to accommodate a fixed depth at the end of the girder (i.e., the 300 mm or 350 mm shown in Figure 4.7.1.4-2), then the larger girders will require more sizing at the ends than the preferred limits of Figure 4.7.1.4-1.

![Typical 350 mm-450 mm Girder Sizing](image2)

**Figure 4.7.1.4-2  Typical 350 mm-450 mm Girder Sizing**

Typically, girders are specified by minimum end (butt) diameters and it is not uncommon for a range of sizes, increasing upwards from the minimum, to be supplied. In addition, with the limited availability of high quality girders, specific sizes should not be ordered except in small quantities. Therefore, accommodation must be made for a possible range of sizes depending on the application, as will be outlined in the following sections.
4. 7.1.5 Replacement of Existing Round Timber Girders

Replacement of individual girders in an existing bridge will usually require the maximum finished depth of the girder at the supports to match the existing members. In most cases, this will be similar to that shown previously in Figure 4.7.1.4-2. In order to accommodate larger diameters, the maximum limit for “B” given in Figure 4.7.1.5-1 should be used. This chart has been generated to allow increasing notch depths (as a percentage of the diameter) for the larger sizes. The limits range from 15% of the diameter for a 350 mm girder to 20% of the diameter for a 550 mm girder. This is based on the condition that the girders are of mixed sizes ranging from 350 mm to 550 mm. Where more material is to be removed than allowed by this chart, it shall be removed from the top of the girder only.

The minimum depths “B” given in Figure 4.7.1.5-1 will provide a minimum flat width of at least 50% of the diameter which will ensure adequate bearing capacity for the respective girder sizes.

![Figure 4.7.1.5-1 Limits for Depth of Support Notch “B”](image)

**Figure 4.7.1.5-1** Limits for Depth of Support Notch “B”

4. 7.1.5.1 Round Timber Girders for New Bridges

With new timber girder bridges, or where all girders in a bridge (or span) are to be replaced, there are several adjustments that should be considered:

- all girders should be obtained before the work is commenced
- all the larger diameter ends should be placed at the same support
• sizing of the girders should be in accordance with the details specified in Subsection 4.7.1.4 (except as noted below)
• the elevation at each support should be selected (or adjusted in existing bridges) to suit the largest diameter at that support
• spacer blocks should be used under smaller members

This action will facilitate proper sizing of the girders as well as accommodating for future girder replacements. In the future, the spacers can be adjusted to suit different girder sizes.

An example of the end sizing for a bridge composed of a range of girder sizes is shown in Figures 4.7.1.5.1-1 and 4.7.1.5.1-2. This arrangement would set the fixed depth at the ends to 350 mm and 400 mm for the small girder ends and large girder ends, respectively. This bridge would satisfy a wide range of girder sizes in the future.

All girder sizing meets the requirements of Subsection 4.7.1.4 except the largest diameter which has been sized to meet the limits given in Figure 4.7.1.5-1. Basically, the use of such a large girder is inefficient and should be avoided when combined with smaller sizes. Note that for the 550 mm end, the notch depth B is 20% of the diameter and the rest of the sizing is taken off the top.
Figure 4.7.1.5.1-1 Sample Sizing for Large End Diameters
4.7.1.6 Bolting and Alternate Attachments - General

All bolt holes represent moisture traps and should be preservative treated as outlined in Section 1. For all deck attachments, through holes in the girders should be avoided wherever possible, particularly vertical holes. The use of coach screws instead of bolts provides tighter holes and reduces the chances of moisture entry and some examples are provided in the subsequent sections.

Figure 4.7.1.5.1-2 Sample Sizing For Small Diameter Ends
In addition to avoiding through holes, it is beneficial, for maintenance purposes, that tie-downs be detailed to facilitate retightening as well as future component replacement.

4. 7.1.7 Attachment of Sheeting

The attachment of longitudinal sheeting represents one of the most difficult challenges with respect to durability, particularly for sheeting directly over the girders.

4. 7.1.7.1 Attachment of Sheeting Between Girders

In between girders, the sheeting can be attached directly through the decking only. The bolts should be drilled between the decking members as shown in Figure 4.7.1.7.1-1. This will reduce access of moisture to the supporting deck planks.

![Figure 4.7.1.7.1-1 Attachment of Sheeting Through Decking](image)

4. 7.1.7.2 Attachment of Sheeting Through Girders

For sheeting over girders, the typical method is to drill through the girder. However, this should be avoided wherever possible. Flashing on the top of girders should not be used if holes are to be drilled through the girder. Where moisture can gain access under the flashing, the flashing will resist drying and enhance deterioration.

While one bolt should be used at the end of each sheeting component over a girder, as outlined in Subsection 4.5.1.2, typically two bolts are eventually used to ensure that the sheeting lies flat at the butt joints. This means that up to four bolts can be needed at the butt joint in sheeting over a girder. An alternative method is shown in Figure 4.7.1.7.2-1. This uses a thin steel cover plate with a small perpendicular web which fits into the gap between sheeting at the butt joint. Usually it can be secured using only a single (M20) bolt (through the girder) to hold down the ends of both sheeting components. This reduces the number of holes through the girder.
A proposed detail is shown in Figure 4.7.1.7.2-2 using 6 mm plate. Two holes are set to one side to allow a choice of orientation (rotation) of the plate and choice of hole to suit the field conditions. Wherever possible, drilling through the girder should be avoided.

One other alternative would be to use coach screws in the sheeting above the girders which do not penetrate the girder, only the decking. However this would require the decking material to be in very sound condition.

4. 7.1.7.3 Re-orientation of Sheeting and Attachment of Sheeting

Another alternative for the sheeting would be to change the orientation to run at an angle to the girders. This can only be done where all the sheeting over a specific length of the bridge is to be replaced.
Typically, the sheeting requires attachment using two bolts at each end and single bolts on a staggered pattern of at least 1.5 m spacing along the component as specified in Subsection 4.5.1.2. In addition, the minimum offset between butt joints is at least 500 mm. To satisfy these requirements and avoid holes through the girders, the sheeting would have to be rotated at least 25 degrees from the longitudinal. However, rotating the sheeting to 45 degrees would provide considerably more flexibility for placement of the sheeting. It is not practical to display any details here as the layout will depend on the lengths and widths of the sheeting as well as the girder spacing.

4. 7.1.8 Attachment of Decking

Since the decking typically runs perpendicular to the girders, there is no need to attach it directly through the girders. The decking should be attached to bolting strips, as shown in Figure 4.7.1.8-1, and subsequently these bolting strips, or the decking itself, be secured to the girders using one of the methods outlined in the figure. Usually one bolting strip is placed adjacent to each girder.

![Figure 4.7.1.8-1 Typical Methods of Decking Attachment](image)

The upper sketch in Figure 4.7.1.8-1 shows a traditional method using cross members under the girders. An example of this approach using steel cross members is shown in Figure 4.7.1.8-2 where the cross member is attached using bent threaded rod formed over the girders as shown in the figure. This is not aesthetically attractive nor is it practical in cases where the bridge may be subjected to flooding.
Another approach, which is shown in the bottom sketch of Figure 4.7.1.8-1, is to place the bolting strips close to the girders and then use straps or similar bent rods to secure the decking to the girder. This method requires less components and avoids the need to use cross members in cases where flooding is likely.

**4. 7.1.9 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 by avoiding holes through the girder far outweighs the additional cost.

It is estimated that the life expectancy of a girder in a traditional timber bridge would be at best 20 to 25 years and, in many cases, even less. However, with no through holes, the addition of flashing and regular maintenance, it is believed the average girder life could easily reach 40 to 50 years.

The following sections outline a number of alternative approaches which may be used in various situations. These are only intended as a guide and there are numerous permutations that can be developed. In all cases, it is essential that some engineering evaluation be combined with the new details to ensure that the connections satisfy the design loads for the bridge under consideration.

**4. 7.1.10 Girder Attachment at Abutments**

A possible alternate attachment for girders at abutments, or at other locations without corbels, is shown in Figure 4.7.1.10-1. This provides a number of benefits:

- it avoids through holes in girders
- places holes under the cross girder providing improved protection
- allows easy access for retightening
- facilitates removal and replacement of the girder

Figure 4.7.1.10-1 Coach Screw and Steel Angle Attachment to Headstocks and Capwales at Abutments

The component sizes should be properly engineered for the design (braking) loads. However, a minimum of M20 coach screws should be used in the vertical direction to enhance withdrawal strength and durability. A fairly heavy bracket with gussets should be used to provide a rigid component with a reasonable bearing area, and to allow the coach screws to be diagonally off-set.

Some examples of stronger connection details, using girder side brackets, are provided in the next section for girders and corbels. These could also be modified to suit abutment supports.

4.7.11 Girder and Corbel Attachment at Piers

Figure 4.7.1.11-1 shows one approach for the attachment of girders and corbels at pier supports. Attachment of the corbel to the headstock or capwales would be similar to the method used for girders in the previous section. The girders would be secured to the corbels using M20 bolts and steel angle brackets which would be coach screwed to the sides of the girders combined with small steel channel beams under the corbels. While some component sizes are shown in the figure, it would still be necessary to determine the proper sizing of the attachment for the design loads.

Note also the need for a drift pin passing up through the corbel into the girder. At least one should be used on either side of the pier to ensure the girder and corbel remain aligned in the event the tie-down should loosen.
A modification to the previous example is shown in Figure 4.7.1.11-2 where one of the girder attachments is integrated with the support tie-down. This detail provides the same benefits as the previous alternative and reduces the number of components required.

Another modification to the previous examples is shown in Figure 4.7.1.11-3 where the end attachment between the girder and corbel is simplified to a bent...
threaded rod. This detail provides the same benefits as the previous alternative and again reduces the number of components required.

**Figure 4.7.1.11-3  Alternate Girder and Corbel Attachment - Example 3**

A further modification to the previous examples is shown in Figure 4.7.1.11-4 where the attachment to the girder uses a threaded rod or bar over the top of the girder. This detail provides the same benefits as the previous alternative and again reduces the number of components required.

**Figure 4.7.1.11-4  Alternate Girder and Corbel Attachment - Example 4**

These are only several examples of the alternative types of attachments that can be used to avoid through holes in girders and corbels. There are many variations and combinations, and these examples are intended only as a guide. The detailing will depend on the types of equipment available as well as the design loads which must be satisfied.
4. 7.1.12 Preservative Protection

Section 8 provides details on preservative types and applications and Section 1 outlines the general requirements. In girder bridges, particular attention should be given to:

- bolt holes in girders where they cannot be avoided
- ends of components, particularly girders
- interfaces between sheeting, decking and girders
- under the bearings of girders
- under flashing when fitted along girders and corbels

A gel or grease type remedial preservative should be used between surfaces and in holes, particularly areas which will be difficult to access in the future.

4. 7.1.13 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 penetrates the protection. In most traditional girder bridges, flashing is not used due to the numerous holes intersecting the interfaces between the sheeting, decking and girders.

However, flashing should be used on girders and corbels where the methods of attachment outlined in Subsections 4.7.1.10 and 4.7.1.11 are used.

The timber surface under the flashing should be treated with a gel or grease type remedial preservative and the flashing should not be perforated by any holes. Lap joints should be effectively sealed to prevent moisture ingress.

4. 8 SPECIFICATIONS

Section 1 lists the relevant specifications applicable to timber bridge construction.

4. 9 MATERIAL SUPPLY

Section 1 provides the basic material supply requirements for timber bridges. Except as noted below, or otherwise specified, the material requirements and specifications outlined in Section 1 shall apply as minimum requirements for 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.

4. 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.

4. 9.2 Steel Components

All steel bolts, rods and bars shall be minimum grade 4.6 and hot dip galvanised or otherwise protective treated.