5 TIMBER

5.1 GENERAL

Timber bridges once formed a major part of New Zealand's roading network. While many of the original timber bridges have been replaced with concrete and steel structures, timber is still a significant component of this country's bridge stock.

Figure 5.1: Timber truss bridge comprises timber members bolted together.

Timber has been used in all parts of bridge structures, and in a wide range of structural types. Structural form is largely dictated by the size of the timber members that can be cut from the natural timber source, the imagination of the designer and the skill of the builder. Timber has been used for piles, piers, abutments, beams, trusses, decking, kerbs, and rails, both in all-timber bridges and in combination with steel and concrete. A more recent trend is lamination of timber members using glue, nails, bolts, or stressing tendons to provide larger and more rigid structural units.

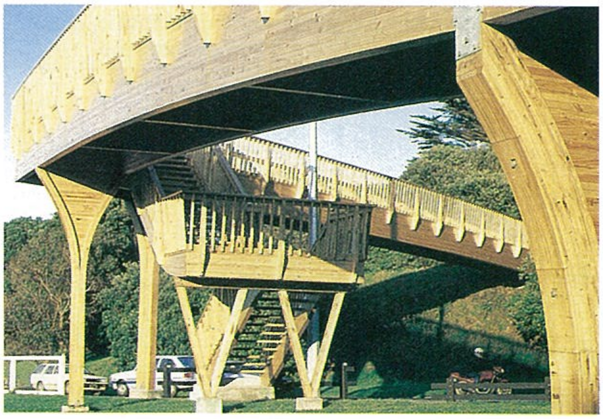

Figure 5.2: Laminated timber bridge has many small parts glued together.

A New Zealand-wide survey of bridges found that timber components consistently showed the highest percentage of defects.

Decay is the most serious timber defect and is the reason for most timber bridge maintenance needs.

Timber as a bridge building material is not durable unless it is appropriately treated and well maintained.

Most timber bridges in New Zealand are constructed from "Mixed Australian Hardwoods" and New Zealand heart native timbers. Some, however, including major structures, have preservative-treated radiata pine components. Because of their greater age, the former tend to have more defects requiring maintenance than the latter.

Some preservative treatments used before the mid-1960's involved formulations and processes now considered to be inferior. Defects, particularly in decks, can be expected in structures containing these treated timbers.

5.2 MATERIAL PROPERTIES

5.2.1 Structure

Timber has unique material properties, related to its cellular structure, which must be appreciated for successful evaluation of its in-service condition. Timber is a natural material of elongated cellulose cells cemented together with lignin to form a hard and rigid structure. This cell structure, the product of growth in the trunk of the tree, varies depending on the species of tree, the age of the tree, the climate and the growth conditions. The cell structure gives rise to physical properties of the timber which differ longitudinally, radially, and tangentially to the growth rings.

Properties vary with the location within the trunk – the outer layer cells (sapwood) function as living cells by conducting sap, and older cells of inner layers die off (to form heartwood), become less permeable and deposit extractive chemicals which govern properties such as water repellancy and decay resistance.

Branches originate from the pith of the trunk and give rise to knots.

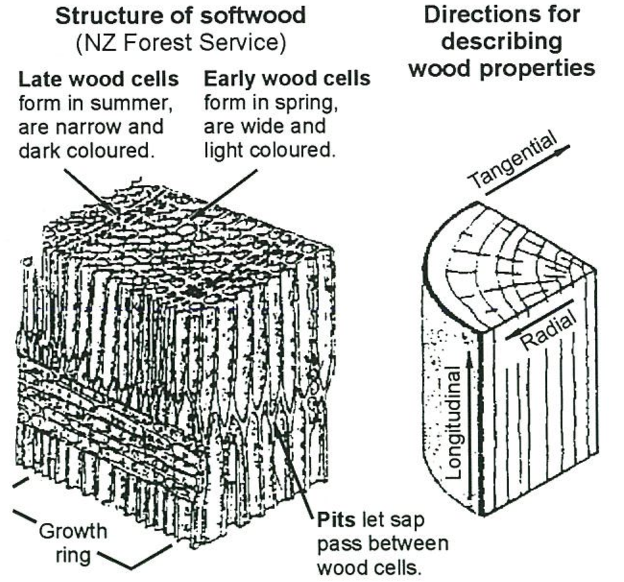

Figure 5.3: The cell structure of timber influences the material properties.

5.2.2 Species

There are many different species or types of timbers with widely varying properties. Most older bridges in New Zealand were constructed of Australian hardwoods or New Zealand heart native timbers. More recently, new timber in bridges has been treated radiata pine.

5.2.3 Moisture Content

The fibres and cells of freshly cut (green) timber are saturated and moisture content (m.c.) ranges from 50 to 200%. As timber dries, the moisture from the cell cavities evaporates until the fibre saturation point is reached at m.c. in the range 25 to 30%. The timber dries further to the equilibrium m.c. of approximately 15%.

5.2.4 Moisture Movement

Below the fibre saturation point timber shrinks as it loses moisture and swells as it gains moisture. Above fibre saturation point there is essentially no dimensional change with m.c. variation.

Dimensional changes with m.c. variation are greatest in the tangential direction and least in the longitudinal direction.

5.2.5 Density

Density of timber is controlled by size and thickness of the cell structure and varies within a tree, from tree to tree, and from species to species.

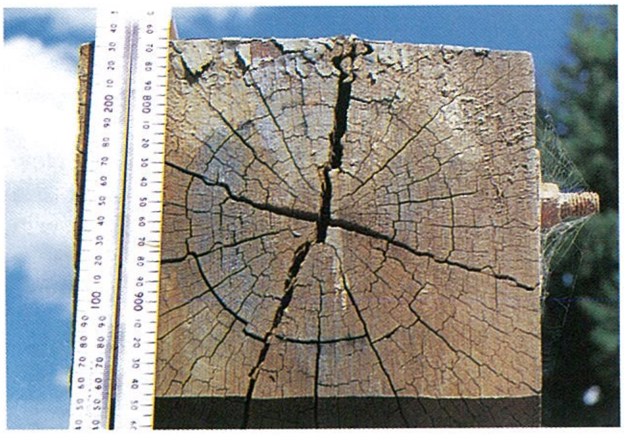

Figure 5.4: Timber shrinkage causes tensile failure across the grain.

5.2.6 Thermal Expansion

Timber has a low coefficient of thermal expansion, approximately one third that of steel or concrete.

5.2.7 Strength

The strength of timber is very variable, and is influenced by orientation of cell structure, size of member and presence of defects. A strong piece may have up to ten times the strength and five times the stiffness of a weaker piece. Allowable code design stresses are based on the strength of the weakest pieces, and allowable stiffness is based on the average modulus of elasticity value.

The wood structure may be thought of as parallel hollow fibres like a bundle of straws. In compression parallel to the grain, the fibres buckle resulting in ductile failure, while in compression perpendicular to the grain the fibres progressively crush until the cells are fully compressed. Wood is

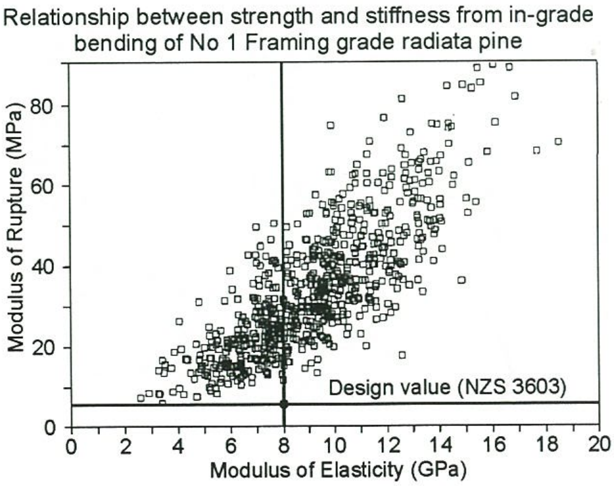

Figure 5.5: The strength for one species of timber can vary by a factor of 10.

strongest in tension parallel to the grain but fails with a rapid brittle fracture. It is weak in tension perpendicular to the grain, with failure resulting from splitting between the wood fibres. Any defect, natural or induced, may greatly reduce strength. Strength is also affected by duration of load, temperature, and moisture content but is relatively unaffected by fatigue.

5.2.8 Durability

Timbers vary greatly in their natural resistance to decay. Heartwood of some species such as iron-bark, teak, and redwood is very durable whereas other species such as radiata pine have very little natural resistance to decay. Sapwood of all species must be regarded as perishable.

5.2.9 Glue-Laminated Timber

Manufacture of large structural timber members by glue lamination from many smaller pieces has generated the resurgence of timber as a structural material for many types of construction including bridging. The process gives benefits of better penetration and treatment for durability, multimember load sharing for improved strength, elimination of physical defects, better drying and elimination of shrinkage defects, higher strength to weight ratio, lower temperature movements, versatility and enhancement of sizes and shapes, and enhanced natural appearance.

5.3 DEFECTS

Many defects found in timber bridges may be explained by consideration of the material properties, coupled with installation and usage circumstances.

Figure 5.6: Decay is the most serious timber defect.

5.3.1 Decay

Decay is the most serious timber defect and is the main cause of timber bridge replacements. Decay is the rotting of timber as a result of fungal attack. The cellulose materials or wood sugars, the main constituent of timber, are a food source for a variety of fungi.

Advancement of decay requires the presence of fungal spores, oxygen, temperatures in the range 20°C to 30°C, moisture content greater than 20% and a non-durable timber food source. Durability depends on a number of factors including species, age and source. Treatment of softwood such as radiata pine to the appropriate hazard class (MP 3640:1992) is the best assurance of good durability for new timber.

Figure 5.7: Decay in laminated macrocarpa deck after 10 years.

5.3.2 Splits, Checks, Shakes

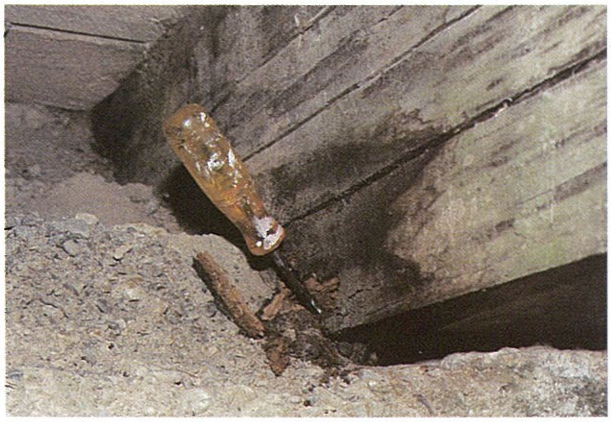

Figure 5.8: Accumulation of gravel, splits and advancement of decay at bearing area of timber beam.

Splits, (separations along the grain extending right through the member), checks (surface cracks on one side of a member), and shakes (cracks between annual growth rings), result from the weakness of timber to tension across the grain and differential shrinkage during drying.

5.3.3 Sloping Grain

Sloping grain, which is grain not parallel to the member axis, may result either from the natural growth of the tree or the way the timber was sawn. Sloping grain means a discontinuity in the timber fibres and hence lower strength.

5.3.4 Knots

Knots reduce the effective member cross section and cause local areas of sloping grain with a consequent decrease in most mechanical properties.

5.3.5 Accumulations

Any build up of dirt, vegetation, or water has an influence on the drying and equilibrium moisture content of the timber and can hasten cracking and deterioration of the timber.

5.3.6 Holes

Any holes, either from boring insects, nails, spikes, bolts, or drilling investigation , provide the means of access for the natural elements that cause deterioration of the surrounding timber cell structure.

Figure 5.9: Drill hole, accumulation of road gravel, vegetation growth, and decay in deck planks.

Figure 5.10: Splits in painted macrocarpa rail and moss growth after 10 years.

5.3.7 Connections

Timber structures depend on members effectively connected together. Connections may involve holes, foreign materials such as bolts, and concentration of loads and stresses. They are a likely location of defects from crushing of the timber grain, chemical attack of the timber cell structure, corrosion of steel fixings, splitting of the timber member from the wedge action of nails and spikes, and decay from the access of moisture and oxygen into the joint.

5.3.8 Looseness

Looseness, usually associated with movement in a joint or failure of spikes to hold members firmly, can lead to progressive deterioration of the structure and be hazardous to users.

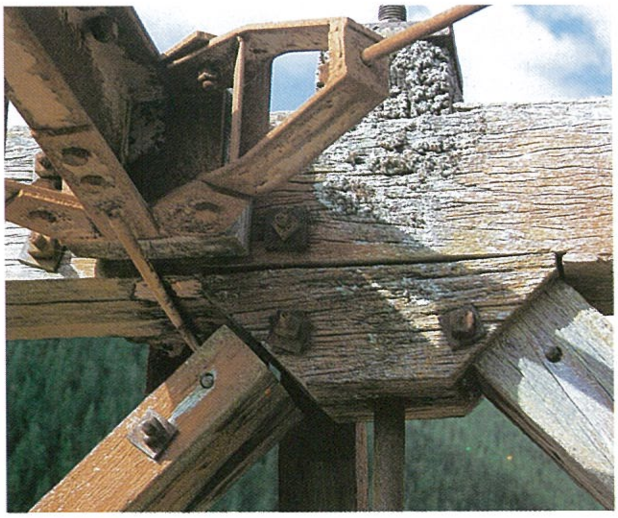

Figure 5.11: Joint defects: movement from compression, looseness of tension member, open holes from investigation drilling, corrosion of steel fixings, moss growth and decay.

5.3.9 Misalignment

Misalignment, either sag in main beams or trusses, lateral bucking in truss compression chord members, or abrupt misalignment of secondary members such as kerbs and rails, is an indicator of some problem of failing capacity and performance.

5.3.10 Abrasion

Mechanical wear and loss of section may result from traffic effects on deck timbers, which sometimes result in an undesirable slipperiness, or from stream-bed movement on piles.

5.3.11 Vehicle Impact

Timber kerbs and rails are very subject to damage by vehicle impact.

5.4 INSPECTION

The aim of inspection is to identify all defects present, to establish their causes, and to evaluate their rate of advancement, so that this can be followed up with an assessment of seriousness and programming for remedial action required.

Preliminary information relevant for inspection of timber bridges includes:

- Age of structure;
- Original drawings and subsequent treatment and repairs;
- Prior inspection, drilling, and assessment history;
- A schedule of all main timber components.

A visual inspection would include a thorough search for any of the following defects:

- Accumulation of dirt, vegetation or dampness on any joints or surfaces;
- Drainage defect that might add to dampness of timber components;
- Decay particularly at joints or areas of possible dampness;
- Cracks or splits that might aid moisture penetration and retention in the timber;
- Insect or borer infestation;
- Loose joints or corrosion of metal components;
- Movement between deck and stringers or looseness of running planks;
- Abrasion of the deck surface or piles;
- Soundness of painted or coated surfaces.

Figure 5.12: Old timber superstructure with an assemblage of beams.

Figure 5.13: Large split at bearing area of beam greatly reducing load capacity in shear.

Figure 5.14: Maintaining a sound painted coating is a problem on old timber rails.

Where any watermarks, stains, or moss growth suggest possible areas of decay, particularly at joints, ends of beams and ground contact areas, such areas should be probed with a long, thin, sharp steel instrument, sounded with a hammer, and suspect areas followed up with discrete drilling or coring. The pilodyn instrument which fires a spring-loaded pin, can be useful in obtaining a measure of resistance to penetration which may be related to density and hardness.

An electronic moisture meter can show which timbers are moist enough to be at risk from fungal decay. A number of other instruments and techniques are available but are more suited to research or special investigations for reasons of time and cost.

Exploratory boring is necessary to confirm the presence of decay and to estimate the dimensions of sound timber that remains. Drilling with a sharp auger is the most common method but the shavings are difficult to interpret. Methods that produce an undisturbed core from a borer or plug cutter are recommended. Drilling should be at locations where decay is likely to occur. Over-drilling must be avoided and drill holes must be treated with preservative and plugged with treated dowels.

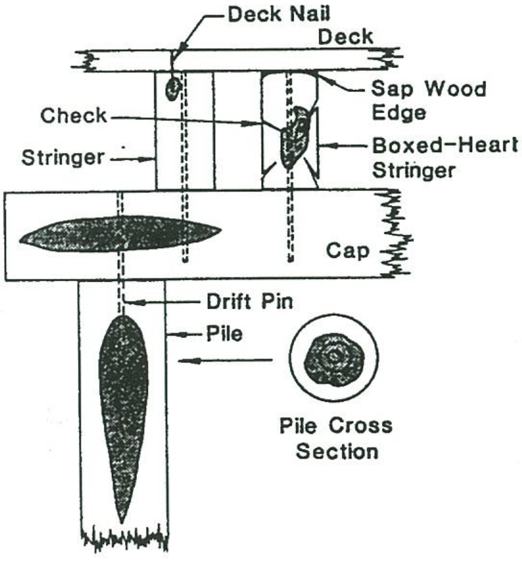

Figure 5.15: Locations where decay is likely.

The objective is to identify defects and measure them for assessment purposes. Measurements must be thorough and attempt to fully define all observations with a schedule covering all main members of the structure, recording location, extent, rate of change and assessed effect on performance.

5.5 EVALUATION

Evaluation of timber structures is in most cases a complex task which, after consideration of all the best information that is available, may still involve a large degree of uncertainty and rely largely on experienced engineering judgement. It is important that conclusions are practical and economic. Sometimes an evaluation will suggest that bridges that have been satisfactorily carrying Class 1 vehicles should be restricted to light vehicles only, and too often major and expensive repairs are carried out on timber bridges that in reality are in need of early renewal.

Figure 5.16: Old timber bridge with relatively new treated radiata pine decking.

Evaluation requires the assessment of allowable timber stresses. Standard allowable design stresses are the basis for assessment, with judgement based on a number of specific member and site conditions including:

- Species and grade of timber member;
- Size of member with allowance for defects such as splits, knots, abrasion and decay. No effective stress capacity should be assumed in identified areas of decay;
- Function and importance of member either as primary member, e.g. main beam, or secondary member, e.g. deck plank, and degree of load sharing;
- Traffic intensity and frequency of heavy vehicle and overloads;
- Size and importance of structure;
- Degree of risk in event of member failure;
- Type of member and the reliability of stress assessment;
- Performance record both historic and by proof loading;
- Programmed intention for replacement.

It may be helpful to assess upper and lower bounds for allowable stresses and complete the evaluation for these two cases.

Figure 5.17: Old bridge with load restriction.

Analysis of all members is required to assess the safe allowable loading for the bridge. Procedures should follow those set out in the Transit New Zealand "Bridge Manual" (SP/M/014).

Old timber has a limited life. Evaluation should aim at quantifying allowable vehicle loads, and lead to the determination of a maintenance strategy and the appropriate time for repair or replacement. For old timber bridges with obvious evidence of decay there is usually a problem of determining where to stop once member replacement is started. The main objective of evaluation is then to determine when total bridge replacement is necessary.

Figure 5.18: Old truss bridge beyond its life limit for vehicles. Some old bridges have a heritage value and deserve preservation, possibly for pedestrian use.

5.6 PHILOSOPHY OF REPAIR AND MAINTENANCE

The extent and location of defects detected during inspection will be the major influence on the repair and maintenance strategy. The success of any repair programme will depend on knowledge of why the defect has occurred and the measures taken to prevent its recurrence. Experienced judgement is very important. Maintenance may be divided into three categories:

- Structural repair;
- Rehabilitation and replacement;
- Preventative maintenance.

Often old timber bridges have a history of neglect, and rehabilitation or replacement are the only viable options.

The key to a successful repair and maintenance programme for hardwood bridges is management of the interaction of water with the structure. For softwood bridges, it is the use of correctly treated replacement timber. A continuing and systematic monitoring programme must be instituted because any design solution hinges on an on-going commitment to inspection.

Timber bridges form a part of the historical and cultural heritage of this country. Some attention has been given to preserving and restoring some of the best remaining examples of older timber bridges. Obtaining suitable identical replacement timber is usually a problem and other species have been used.

5.7 REPAIRS – GENERAL

Timber is used in many applications and forms all components in many bridges. Structural repairs will depend on the cause of the defect and on the function and circumstances of the component in relation to the structure. Each case requires specific assessment and experienced judgement.

5.7.1 Vehicle Impact Damage

Some timber components – deck planks, running planks, kerbs, rails, posts – may be broken by vehicle impact. Usually replacement of the broken member is required.

5.7.2 Protection of Deck Surface

Timber deck members are affected by mechanical wear and become slippery. A bitumen seal or concrete overlay will help protect from wear as well as providing a water-resistant cover.

5.7.3 Splitting of Members

Timber is weak in tension across the grain and is vulnerable to splitting from ends of members through bolts and connections. Seal ends, treat surfaces to prevent decay, fill openings with epoxy, grease and tighten bolts. Galvanised steel splice plates may be required to restore structural unity and prevent further splitting.

5.7.4 Pile Damage

Timber piles may suffer at bed-level or water-level from insect attack, abrasion, and decay. Repair may involve timber preservative coatings, filling of holes, jacketing with concrete, fixing steel or timber splices, or replacement of the member.

5.7.5 Connections

Timber connections become loose from the many factors that concentrate loads at these positions. Connections need to be kept tight and sealed, and any defective components repaired or replaced.

5.7.6 Delamination

Nail-laminated decks become de-laminated through movement or shrinkage. Prestressing may restore the load distribution characteristics of the deck and also provide a water-tight surface.

5.7.7 Replacement of Member

When a timber member has been neglected and has become split or seriously decayed, the only option is replacement. The replacement timber member may be a similar species, new or recycled, treated radiata pine, or glue-laminated. Many factors of function, cost, capacity, effectiveness, life expectancy, availability and practicality need to be considered in deciding the best solution.

5.8 REPAIRS – DECAY

Three broad strategies are available for structural repairs required because of decay of timber bridges:

- Replacement of decayed members;
- Reinforcement of decayed members;
- Eradication of decay in affected members and prevention of its recurrence.

In many cases a combination of at least two of these strategies will be necessary.

5.8.1 Replacement of Decayed Members

Replacement will be necessary when the extent of decay has reduced the residual strength of the affected member to an unacceptable level. Unfortunately, little practical information is available to correlate extent of decay with strength loss, and the decision to replace must be appraised in relation to the type and intensity of stresses imposed on that portion of the member which contains decay.

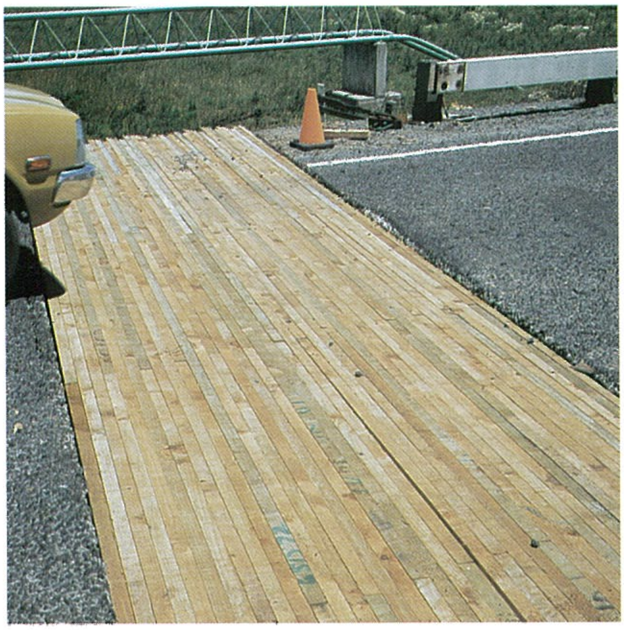

Figure 5.19: Replacement sections of radiata pine nail-laminated deck.

Figure 5.20: New timber spliced to raking pier member.

When the decayed member is removed, all adjacent timbers must be checked to ensure that decay has not spread from the defective member. It is important to remove completely any possible source of future infection. Thus, if repair involves cutting out obviously decayed sections of affected members, it is necessary to remove at least 500 mm, in the grain direction, of apparently sound wood since it is likely that hyphae (thread-like elements) of decay fungi have penetrated that far from the obviously decayed zone.

(a) *Replacement with Preservative Treated Softwood.* All replacement timbers must be treated in accordance with provisions in MP 3640:1992. Any replacement timbers above deck level should be treated to Hazard Class Specification H3; deck timbers, including running planks, to Hazard Class Specification H4; and any part of the superstructure which comes in contact with soil, or which will have a permanently high moisture content, to Hazard Class Specification H5. Replacement piles in fresh water should also be treated to Hazard Class Specification H5, but in estuarine or sea water replacement piles must be treated to Hazard Class Specification H6.

(b) *Replacement with Naturally Durable Hardwoods.* If it is necessary to replace decayed hardwood with similar material, only new timber of Durability Class 1 or 2 should be used. It is unwise, other than for temporary repairs, to replace decayed hardwood members with those salvaged as apparently sound from other structures. Experience has shown that the residual life of such timber may be far less than anticipated at the time of salvage.

5.8.2 Reinforcement of Decayed Members

Occasionally it may be impractical to replace decayed members because of their location in the existing structure, but reinforcement with a parallel member or other bracing may be feasible. Because infection can spread from one member to another, untreated naturally durable hardwoods should not be used as reinforcement in close proximity to decayed members unless decay eradication procedures have been applied to the original member. Steel, preservative-treated softwoods, or concrete are preferred alternatives.

A thorough structural analysis is required to ensure the capacity of the repair and verify load distribution to members. Situations that introduce eccentric loads or tension perpendicular to the grain should be avoided.

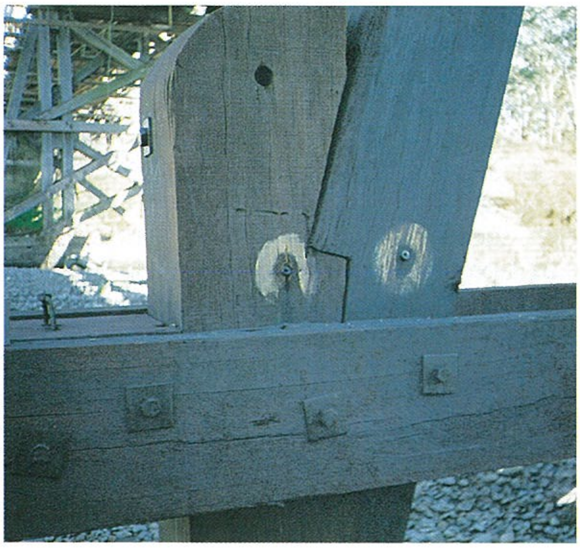

Figure 5.21: Repair to base of raking pier member.

Figure 5.22: New bracing provides additional support to an old hardwood superstructure.

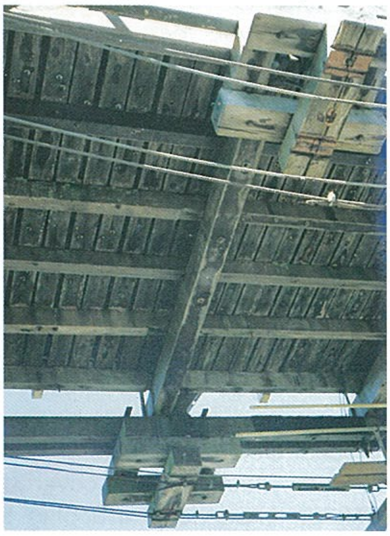

Figure 5.23: Reinforcement of truss with tensioned wire rope.

5.8.3 Epoxy Repairs

Epoxy resins can be used for timber repair as bonding agents (adhesives) or grouts (fillers) in both structural and semi-structural repairs. They may be injected under pressure or manually applied as a gel or putty. Epoxies are most effective for structural repairs in dry locations when used as a bonding agent to provide shear resistance. When used as a grout for filling decay voids, it is essential that all decayed wood is removed, that moisture conditions which caused decay are rectified, and that surfaces are treated with preservative.

5.8.4 Eradication of Fungal Infection

(a) Control of Moisture

In the early stages of decay, all that may be necessary to arrest its development is removal of the source of moisture, allowing the timber to dry to below 25% moisture content, and prevention of re-wetting. For example, drainage patterns on approach roadways can be re-routed to channel water away from the bridge rather than onto the deck.

Cleaning dirt and debris from the deck surface, drains and other horizontal components also reduces moisture trapping.

(b) Fumigants

Fumigants such as vapam and chloropicrin have been used successfully in the USA for eradicating internal decay in Douglas fir roundwood. However, they are unlikely to be effective in hardwoods and will have only limited relevance to preservative-treated softwoods such as radiata pine where decay will be initiated at surfaces rather than internally. Fumigants do not provide long-term protection.

(c) Diffusible Fungicides

Several proprietary formulations are available. These are either gels or thick liquids based on fluorine, copper and boron salts, or fused rods of borate salts. Gels and liquids are applied to timber surfaces which are then covered for 5-6 weeks with an impervious wrapping to allow the chemicals to diffuse into the wood. Boron rods are inserted into holes drilled into the affected member and the holes are then sealed.

Figure 5.24: Application of diffusible fungicide (Boracol) prior to installing concrete overlay.

The principle behind both procedures is that the high wood moisture content, which has allowed initiation of decay, will act as a medium through which the fungicides diffuse and kill the decay organisms.
If there is no moisture there will be no diffusion and no decay. The fungicide will remain indefinitely and begin to work if moisture reaches the area. However, it must be noted that diffusible fungicides that are not “fixed” into the timber will be leached out if the timber is exposed to continuing moisture penetration. Retreatment will be necessary, with frequency depending on the degree of exposure. Brush-on surface treatments have not been proven for Australian hardwoods.

5.9 REHABILITATION AND REPLACEMENT

Many timber bridges reach an age and condition for which preventive maintenance is not appropriate and structural repairs are no longer cost-effective. It the structure is sub-standard and load restrictions apply, it is the appropriate time to review the options of major repair, rehabilitation, and replacement.

A typical case might be an old timber bridge where the running planks are loose, the deck planks below are decayed and will not hold spikes, the stringers are cracked, and zones of decay have been confirmed. Load capacity is in question and further weight restriction is not acceptable. The foundations are sound.

Figure 5.25: Preparation for concrete overlay.

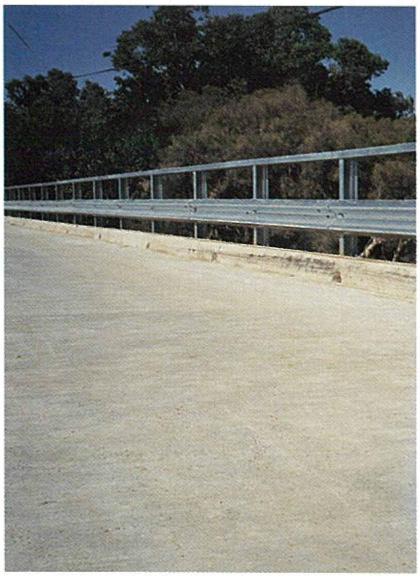

Figure 5.26: Concrete overlay complete.

Options to consider are:

- The bridge could be propped mid-span as a temporary measure;
- The superstructure could be dismantled and sound members re-used with replacement recycled members as a short-term solution;
- The deck could be removed and additional stringers installed between existing stringers and the deck reinstated, again as a short-term solution;
- A totally new timber superstructure could be installed, using either sawn timber or laminated components;
- Other materials, such as concrete or steel, could be used either on their own or in composite action with timber. The timber deck could be designed to use a concrete deck overlay for good protection to the timbers below but dead load effects must be considered.

The best solution will be based on an investigation of the economics and future expectations for the particular bridge in relation to the durability of its components and the life expectancy of the structure.

5.10 PREVENTIVE MAINTENANCE

Because untreated timber has poor durability, preventive maintenance is very important to protect the timber from the elements that cause deterioration.

5.10.1 Decay

Decay is the most serious defect and the objective is to eliminate conditions that cause decay.

Timber bridges usually need repair because the moisture content of the wood reaches levels conducive to fungal attack. Decay becomes established because either the natural durability of the timber is insufficient for the end-use or, in a softwood member, preservative treatment is inadequate to protect the timber in the particular decay hazard environment. Replacement timbers treated to current wood preservation specifications (MP 3640:1992) should give a service life well in excess of 30 years. However, it is necessary that any timber surfaces exposed during on-site cutting receive liberal applications of an oil-based or solvent-based preservative. Creosote or copper napthenate (Metalex Green) formulations are ideal for this.

The most effective means of preventing decay is to keep the timber dry. This involves simple tasks of cleaning, draining, removal of debris and growth and applying waterproof coatings. Measures to protect against excessive moisture uptake are more applicable to untreated, naturally durable hardwoods used for repair of hardwood bridges. Protective measures are generally unnecessary for softwoods treated to hazard Class H4 Specification and above (MP 3640:1992).

For timber locations that have a high decay hazard and where other preventive maintenance options are impractical, treatment with a diffusing preservative may offer a solution. See 5.8.4 "Eradication of Fungal Infection", page 5-10.

5.10.2 Timber Decks

Ideally, the deck should provide a waterproof cover over the bridge structure. Many timber bridge decks are of transverse planks, often with running planks over and connected by spikes to, the beam system. Shrinkage of timber leaves cracks that trap dirt and moisture and allow water onto the substructure. Measures are required to ensure that decks are watertight and that drainage on decks and approaches is controlled to allow run-off away from the substructure. The deck should be kept clean of loose gravel, debris, or vegetation growth that trap moisture. Trees shading and sheltering the bridge should be cut back. A bitumen or asphalt seal should be maintained wherever possible as a waterproof membrane over the bridge.

Loose timber deck members result in noise, impact loadings, and possible tyre damage. When spikes will not hold, splits or decay are usually found in the timbers below. Loose deck timbers often result from an underlying problem such as substructure decay. The cause of looseness should be identified before undertaking repairs as more major structural repairs may be required.

5.10.3 Kerbs and Rails

Kerbs and rails are often less durable New Zealand native timbers. Maintenance of a good paint system is important. Connections, shaded and end areas require regular attention. Alternatively, treated radiata pine and more durable hardwoods may be left unpainted.

5.10.4 Connections

Connections of timber members are a potential area for problems. It is important to keep surfaces dry, to ensure that steel components are galvanised and that treatments of paint, grease, sealants and plugs are effective.

Organic solvent, water repellent formulations containing fungicides, or oily preservatives such as creosote should be applied in repair work in situations where two or more members overlap to form water-trapping joints. Use of materials such as mastics, 'Malthoid' or paint is only recommended in situations where they will not encourage water entrapment.

5.10.5 Holes Drilled During Inspections

All holes drilled or bored for assessing the interior condition of members should either be extended right through the member to allow drainage, or be flooded with an oil-based preservative such as creosote, and tightly plugged with a preservative treated dowel.

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"Impel Rods" (Fused boron). Fernz Timber Protection, PO Box 88048, Clendon Town, Manurewa.

"XJ Timber Protective" (Water repellent fungicide). Koppers-Hickson Timber Preservatives (NZ) Ltd, PO Box 22-148, Otahuhu, Auckland.