Technical Note 132

Maintenance minimisation guidelines for walking and cycling facilities

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Feedback: Please send your feedback regarding this document to: mr.techdocs@tmr.qld.gov.au

1 Purpose and scope

The purpose of this technical note is to provide operational and best practice guidance on minimising maintenance on walking and cycling facilities. Design guidance is provided in the Transport and Main Roads *Road Planning and Design Manual* Volume 3, Part 6A.

This technical note provides guidelines for the design of walking and cycling facilities to ensure that ongoing maintenance is minimised and that the facilities, and hence walking and cycling networks, are cost sustainable into the future. The guideline highlights common issues associated with cycling facilities and provides guidance on concepts and methods to reduce the likelihood of these issues occurring during the life of the facility.

The development of this guideline drew on existing knowledge and sought out current practice in national and international planning, design and maintenance of cycling facilities. The document has been developed so that information is readily accessible to the key personnel involved in each of these phases of the facilities life cycle.

This guideline is considered as complementary to existing design guides highlighting 'best practice' and does not supersede any existing standards. It is to be used in conjunction with existing design principles and processes.

1.1 Introduction and background

Asset management in the department is aimed at providing, within available funds, facilities such as pedestrian paths and bicycle ways that meet an agreed level of service for the community, including safety, at minimum whole of life cost. This requires that initial cost versus maintenance and operating cost trade off decisions are made to ensure the total cost of the facility over its life is minimised.

This approach has additional community benefits in that it ensures the level of service offered by the facility meets community expectations by ensuring the availability, safety, and ride quality are all maximised at minimum cost.

A substantial capital investment is often required to provide the appropriate pedestrian and bicycle infrastructure. Consequently an adequate maintenance program is needed to maintain these facilities and minimise future maintenance. Where the department retains ownership of bicycle and pedestrian infrastructure, the facilities should be included in the department's asset management program in a similar manner to roads. This will ensure safe and useable facilities and avoid the increasing cost of maintenance or reconstruction as a result of degradation of the asset. Where ownership of these facilities is passed to local government this principle should similarly be applied by them to the management of bicycle and pedestrian infrastructure. User safety is a critical part of an asset management system and there is an emphasis in this guide on addressing safety related maintenance issues in a timely manner to prevent accidents involving injury to the public.

Smooth, debris free surfaces with adequate friction are a fundamental requirement for cycling safety. Most bicycles have no suspension or shock absorbers and many have relatively thin tires inflated to high pressures. As some cyclists using bikeways travel at speeds of around 30 km/h on flat grades and up to about 50 km/hr on downhill grades, a rough, low friction or potholed surface can be particularly hazardous. Factors that adversely affect the quality of the riding surface should therefore be given a high priority in maintenance programs. Similarly, trip hazards on paths used by pedestrians should also be given a high priority for remedial maintenance.

In addition to minimising life cycle costs, and maximising user safety, timely maintenance has the added benefits of:

- maintaining user comfort and minimizing travel times
- improving availability and reliability of the facility as a means of travel, by reducing closures and restrictions induced by damage and maintenance, and
- promoting facility use and the associated health benefits.

Over the life cycle of a pedestrian or bicycle facility, asset managers will plan, design, build, operate, monitor, maintain, and dispose of the asset. It is therefore appropriate that this guide is structured to discuss maintenance minimisation considerations during the planning, design, and maintenance phases of the cycle. In preparing this guide the following major maintenance issues were identified (ARRB, 2013) and are consequently covered in this guide:

- Vegetation issues
- Debris
- Root infiltration/Pavement lifting
- Defective surfaces
- Drainage
- Utility and service access covers
- Vehicle damage
- Cracking
- Markings and signage
- Lighting
- Vandalism, and
- Erosion.

2 Maintenance minimisation

Engineers Australia (2010) found that the quality of Queensland roads was declining due to inadequate investment in maintenance and renewals. This is a common issue in the transport sector and is likely to also apply to pedestrian and bicycle facilities. The expanding departmental bicycle network has a growing need for routine maintenance and will have, in time, a growing demand for renewal. It is unlikely that government investment will keep pace with this growing need and therefore it is critical that maximum value is gained from the limited maintenance funding made available. The key ways of maximising the quality of the existing infrastructure for the available funds are by:

- minimising the maintenance required, and
- maximising the amount of maintenance delivered for the available investment.

The efficiency of the delivery of maintenance is beyond the scope of this guide which focuses on maintenance minimisation in order to minimise whole of life costs and maintain infrastructure quality and level of service.

The reduction of the ongoing cost of bicycle and pedestrian facilities requires a clear understanding of the maintenance required to be undertaken and to which components of the facility they occur. In the development of this guide it became evident that many maintenance issues on bicycle and pedestrian facilities could be grouped into four key areas:

- Pathway Pavement
- Vegetation and Landscape
- Associated Facilities
- Facility Management.

The guide identifies common defects (i.e. aspects requiring maintenance) for each of these key areas and provides guidance on how these defects can be minimised through adequate consideration during facility planning, design, and maintenance. The earlier in the life cycle of a facility that future maintenance is considered the better. It is vital that consideration is given to site characteristics that will influence:

- the life and availability of the facility such as rain fall, runoff, possible flooding, soil types, vegetation, possible geotechnical instability, and slopes in selecting an alignment
- accessibility for maintenance of the facility and surrounding infrastructure including services
- the future usage of the site, including traffic and long term adjacent land use.

Designers and asset managers are key in ensuring that:

- the facility can carry the planned loads including maintenance vehicles
- appropriate materials and features are included in the design to minimise maintenance, and facilitate accessibility for maintenance activities
- landscaping and drainage complement the design and minimise future maintenance issues
- the design incorporates features that address any adverse site conditions.

In consideration of the construction phase of a facility it is assumed that construction details and works procedures are adequately specified and supervised to ensure that detailed designs are correctly implemented ensuring a quality product.

2.1 Pathway pavement

The pavement surfacing of the walking or cycling facility can be made of various materials, including concrete, asphalt, pavers, chip seal or unsealed granular material, while under the surfacing there may be another structural layer of asphalt, granular or cement bound material. On-road facilities will typically have pavements that are the same as the existing roadway; however off-road facilities offer the opportunity to explore appropriate surfacing and structural pavement materials based on the site and demand.

The Australian Bicycle Council in conjunction with ARRB Group undertook research to identify the whole of life costs of the pavement for bicycle paths and shared paths. The report provides guidance on the advantages and disadvantages of a range of pavement types, (Australian Government, 2006). The research noted that asphalt and concrete provided the more preferable riding surface of those reviewed.

The smoothness of the riding surface affects the comfort, safety and speed of cyclists. Pavement surface irregularities can do more than cause an unpleasant ride. Pavement surfaces should be smooth, and the pavement should be uniform in width. Wide cracks, joints or drop-offs at the edge of a travelled way parallel to the direction of travel can trap a bicycle wheel and cause loss of control whilst holes and bumps can cause cyclists to swerve into the path of other traffic (e.g. other bicycles, pedestrians or motor vehicles). In addition, a reduction in the operating speed of the cyclist below a comfortable level results in less stability. As pavements age it may be necessary to fill joints or cracks, adjust utility covers or even overlay the pavement in some cases to make it suitable for cycling.

Maintenance minimisation concepts for the path pavement can be grouped into:

- Pavement surface defects
- Drainage
- Surface transitions
- Vehicle damage
- Root infiltration and
- Cracking.

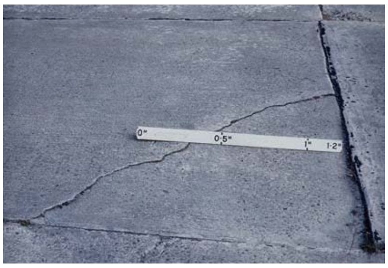
2.1.1 Pavement surface defects

The range of surface defects and the causes can be found in the department's *Road Planning and Design Manual* Volume 3, Part 6A. The likely causes of such distress and treatments are described in *Austroads Guide to Pavement Technology* (AGPT) Part 5: Pavement Evaluation and Treatment Design (Austroads 2009a) which also covers pavement defect investigation, and rehabilitation of surfaced pavements. This publication should be read in conjunction with *Austroads Guide to Pavement Technology* Part 7: Pavement Maintenance (Austroads 2009b) which provides broad guidance on current routine maintenance practices for surfaced pavements. The maintenance of unsealed pavements is addressed in *Austroads Guide to Pavement Technology* Part 6: Unsealed Pavements (Austroads 2009c).

Surface defects allow water to ingress into the pavement material or support material and accelerate deterioration of the pavement. Large defects increase ride roughness and can become a hazard to bicycle wheels and a trip hazard to pedestrians. In order to minimise further pavement damage surface defects should be filled or resealed to reinstate water proofing and evenness until they are programmed for more extensive maintenance such as full width resurfacing, rehabilitation or replacement.

The most common types of defects include cracking, potholes and joint separation. These are illustrated below in the following table along with a description of the likely cause and repair methods. Many defects are a result of poor sub-grade preparation, inadequate drainage or design details that do not suit cycling facilities.

Table 1: Most common pavement path surface defects, description, cause and repair

Typical Distress	Typical Repair	Description and Cause
Asphalt cracking 	• Small cracks can be sealed with bitumen.	**Description**: Interconnected cracks forming a series of blocks approximately rectangular in shape. **Causes**: Asphalt cracking on bicycle paths is generally due to tree root infiltration, fatigue from vehicle traffic and/or sub-grade expansion or weakening usually due to water infiltration.
Concrete structural cracking 	• Slab replacement is usually required.	**Description**: Concrete structural cracking is active cracking which extends through the full depth of the slab. **Causes**: A lack of subgrade support and/or vehicle overloading.
Potholes 	• Potholes are usually patched with hot or cold asphalt mix.	**Description**: A steep-sided or bowl-shaped cavity extending into layers below the wearing course. **Causes**: Potholes in bituminous surfacing are caused by water entering cracks and causing pieces of the pavement to be broken out of the pavement.
Concrete joint stepping 	• Grinding or profiling to correct ride quality. • Resealing of joints.	**Description**: Concrete joint stepping or faulting is a permanent vertical separation of the two slabs on either side of a joint. **Causes**: • inadequate sub-base/subgrade support • moisture movement in expansive clay subgrades • curling and warping of slabs • tree root uplift.
Source: Austroads, 2009, *Guide to Pavement Technology*, Part 5: Pavement Evaluation and Treatment.		

2.1.1.1 Planning phase

Refer to the department's *Road Planning and Design Manual* Volume 3, Part 6A for maintenance consideration in the planning phase. Additional considerations for the planning phase include:

- Consider the conditions and likelihood of flooding events and where necessary consider the appropriate pavement structure, surfacing material and design details to resist the harmful effects of inundation. Concrete is typically more resistant to periodic flooding events than other surfacing options.
- Future activities in the area within the design life of the surface material may accelerate deterioration. In planning, consider future developments and construction works which may affect the facility, such as road widening in areas of high traffic growth. The provision or maintenance of underground utilities (e.g. water, sewer) may also impact on pavement condition.
- Avoid alignments on areas with poor soil characteristic such expansive clays or known issues related to geotechnical stability such as settlement in estuarine areas. Unreinforced rigid pavements can perform poorly and are more difficult to repair than flexible pavements where there is sub-grade movement.

2.1.1.2 Detailed design phase

Refer to the department's *Road Planning and Design Manual* Volume 3, Part 6A for maintenance consideration in the detailed design phase. Additional considerations for the detailed design phase include:

- Use a recognised pavement thickness design system or catalogue of bicycle way pavements to avoid under design of the path pavement. The most comprehensive Australian bicycle path pavement design information is given in the South Australian Department of Transport, Transport Services Division (2011) *Guide to Bikeway Pavement Design Construction and Maintenance for South Australia*.
- Consider the in service design loads of the pavement including maintenance vehicles, sweepers and typical users.
- Ensure that joints are located appropriately for the terrain and conditions.
- Where root infiltration may be an ongoing issue the use of articulated joint systems between rigid pavement slabs or 600 mm deep, high density polyethylene (HDPE) root barriers along the pavement edge for protection from root infiltration (C&CA 2006) is recommended.
- Specify grubbing, subgrade preparation and compaction, and the use of geotextiles to reduce effects that may accelerate crack propagation and other defect development.
- Ensure adequate curing is specified and early trafficking is limited where concrete is used.
- Ensure surface asphalt and concrete mix designs include angular silica sand as the sand size fraction for better surface friction.

2.1.1.3 Maintenance phase

- *Austroads Guide to Pavement Technology* Part 7: Pavement Maintenance (Austroads 2009b) and Part 6: Unsealed Pavements (Austroads 2009c) provide detailed guidance on the maintenance of pavements.

- Immediately repair all cracks to reduce the likelihood of further crack propagation, water ingress and accelerated deterioration.
- Where possible and cost effective, identify and remove the cause of the cracking.
- Crack repairs and propagation minimisation methods should not reduce the level of service to the user.
- Ensure all rigid pavement sealed joints are resealed as required.
- Ensure pavement repairs provide adequate skid resistance and similar friction coefficients to the surrounding surface in both wet and dry conditions for the route.
- When patch repairs are undertaken ensure contractors reinstate surface levels of the repair to match with existing finished levels and the patch is even. Preference should be given to slab replacement rather than patching of concrete pavement.
- Crack sealing with bitumen products should be gritted with angular sand after application and swept to ensure adequate surface friction.

2.1.2 Drainage management

The effective design and maintenance of drainage will assist in the provision of a safe and comfortable surface for bicycle travel. It does this by reducing the rate of pavement deterioration where water is a factor, reducing erosion around the path and water borne deposition of soil on the surface. Importantly, facilities that are prone to being flooded or frequently have water on their surface are less attractive to commuters. Water ponding on the path can also mask potential hazards to users (e.g. potholes).

The department's *Road Drainage Design Manual* provides guidance in relation to the planning, design, construction, maintenance and operation of road drainage structures in all urban and rural environments. It is applicable to bicycle and pedestrian facilities. The maintenance of drainage facilities is also described in *Austroads Guide to Pavement Technology* Part 7: Pavement Maintenance.

2.1.2.1 Planning phase

- Consider commuting users when choosing the facility alignment because they may use the path even when conditions are not favourable such as during adverse weather events.
- Where a short section of path may be subjected to inundation (e.g. path adjacent to a watercourse and under a road bridge to achieve grade separation) ensure a safe alternative at grade crossing is available for use during flooding of the path.
- Where opportunity and space exists, consider implementing water sensitive urban design principles to manage rain events. Importantly consider the water catchment area after the design is complete.
- Identify future activities in the area within the catchment of the facility that may change runoff characteristics.
- Avoid path alignments through areas where drainage is already known to be an issue or ensure that the path is raised on a structure or embankment that avoids frequent inundation.
- Include space for catch and side drains on steep slopes to avoid water flowing over the path surface.

- Consider potential future changes in sea levels when selecting alignments near tidal water bodies.

2.1.2.2 Detailed design phase

- Ensure drainage pipes are large enough to allow cleaning and have sufficient fall to achieve water velocities that will ensure self-cleaning to reduce blocking of drains.
- Ensure path surface height at the lower edge where it meets a grassed area is slightly higher than the verge level to ensure drainage is maintained once the grass grows. As a general principle path pavements should be raised above the natural surface to prevent ponding on the surface and debris washing onto the surface.
- Crossfall of 2 to 4 percent should be adequate to effectively dispose of surface water on sealed surfaces, and 5 percent may be required on unsealed surfaces. Unsealed surfaces will require monitoring after heavy rain fall to identify when they require grading. One way cross fall is preferred for bicycle paths. Be aware that *Disability Discrimination Act* (DDA) requirements specifies a maximum crossfall of 2.5%. A minimum of 1% crossfall is adequate in most situations.
- Ensure adjacent road drainage is extended under the path to avoid discharge near or onto the path alignment.
- Where no alternative exists, consider the use of porous pavements surfacing such as open graded asphalt to reduce ponding events. An open graded surfacing will require edge drains or a free lower edge to allow water to drain from the pavement surfacing.
- Ensure mature vegetation over 3.5 metres tall is set back 2 metres from drainage and 6 metres from a sump.
- Design side draining gullies for on-road bicycle facilities.
- Dome grates should be used on large gully pits away from the path to avoid grates being blocked by debris (Transport and Main Roads, 2005).

2.1.2.3 Maintenance phase

		
Concrete edge drain on slope to remove path and cutting runoff fitted with fence to catch rocks falling from batter.	Above ground cages over drainage pits reduce buildup of debris.	Drainage needs cleaning as well as mowing.

- Develop an event based inspection program for high risk facilities. Where appropriate consider programmed maintenance after first and second flush events where debris levels may be higher.
- Maintain batters and verge vegetation and remove litter to ensure stability and reduce litter in run off.

- Repair any areas adjacent to the path that pond water by draining or filling in order to reduce infiltration into the path pavement or subgrade.
- Where possible direct discharge from mowers and slashers away from drains and gutters to reduce damming caused by the build-up of vegetative matter.
- Ensure grass and other debris does not build up along the pavement margin; thereby preventing surface runoff.

			
Water crossing the path has deposited debris.	Standing water on the path due to a blocked gully pit.	Water ponding on path can mask potholes and other hazards to cyclists.	Flush drain grates can become blocked with debris.

2.1.3 Surface transitions

Refer to the department's *Road Planning and Design Manual* Volume 3, Part 6A for design information on transitions from one surface to another.

2.1.3.1 Planning phase

- Choose an alignment for paths that minimise the number of transitions between the path and bridges and road ways, and changes in materials, especially on curves.

2.1.3.2 Detailed design phase

- Minimise changes in path surface type.
- Ensure rigid pathways are attached flush to bridges or roads via the use of departmental standard drawings and that articulated, tied or dowelled joints are used as appropriate. Ensure all expansion joints are sealed.
- Design as smooth a transition as possible both horizontally and vertically for the best safety outcome. Sharp bumpy curves in which the pavement type changes is the worst possible outcome for users.
- Do not include any vertical lip on ramps or driveways.
- Consider reducing the number of changes of surface type by overlay with the most common material if possible.
- Avoid rounded stone exposed aggregate finishes for concrete pathways because of potential lower wet friction properties.

2.1.3.3 Maintenance phase

- Replace failed joints in concrete pavements at transitions, articulated or tied joints.

- Grind, fill or overlay trip hazards promptly to minimise user trip risks.
- Prioritise bridge inspections on pedestrian and bicycle routes, paying particular attention to ramps and joints.

			
Join at transition has been ground to remove a step due to differential movement. This could have been limited by a tying the two slabs together during construction.	Transition from off –road to on-road at a sharp angle and change of surfacing.	Shape of concrete transition between on-road and off -road paths needs to be widened to facilitate movement between paths.	Service pit repairs can create unwanted surface transitions

2.1.4 Root infiltration management

When trees are grown too close to a path, are of the wrong species or no measures are put in place to prevent roots infiltrating pavement, the roots can lift the pavement creating discontinuities at the joints and cracking. This results in an uneven surface and allows rain water to enter the pavement weakening the subgrade. These disruptions also become trip hazards and create an unpleasant ride. The department's *Road Landscape Manual* (2013) has guidance on setbacks and clearances for bicycle ways in Appendix 4.

2.1.4.1 Planning phase

- Select a new path alignment which avoids existing mature trees that are to be retained.
- On sections of new path where significant existing problem vegetation cannot be avoided by path alignment include allowance in the planning cost estimates for the installation of root barriers along the pavement edge for protection.

2.1.4.2 Detailed design phase

- Non-frangible vegetation greater than 15 m in height to be set back 10 m. Provide a 1 m clear runoff area beside path, turf is preferred treatment.
- Limb dripping species or heavy fruiting/flowering species information may be found in the department's *Road Landscape Manual* Appendix 4 Table.
- Locate replacement trees more than 1 m from the path (to provide shade).
- Specify planting techniques that encourage deep root growth, rather than lateral growth towards the bikeway such as deep ripping prior to planting to break up heavy soil and regular and thorough watering during the establishment period (1 to 2 years), (South Australian Department of Transport, 2011).

- Improve the growing conditions of vegetation and root growth in the opposite direction to the pathway in conjunction with creating a hostile area for root growth under the path by creating a subgrade material with no oxygen, moisture or nutrient holding capacity. Well compacted, bound materials are preferred.
- Select replacement tree species whose mature root systems 'fit' the available volume of soil, moisture, drainage and nutrients in a given area.
- Select species that are proven to have less vigorous root systems.
- On sections of new path where significant existing problem vegetation cannot be avoided by path alignment include 600 mm deep, high density polyethylene (HDPE) root barriers along the pavement edge in the design for protection from root infiltration (C&CA, 2006). Install sodium bentonite or similar root growth inhibitor to base of root barrier and at all joints.

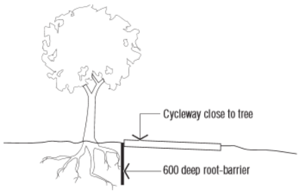
2.1.4.3 Maintenance phase

- Deem a certain pavement vertical displacement unacceptable, undertake inspections and implement appropriate action. Caltrans (2006) recommends that bikeway surfaces not have a step parallel to the direction of travel greater than 10 mm or perpendicular to the direction of travel of 20 mm or a groove wider than 12 mm parallel to the direction of travel.
- 'Make safe' with asphalt ramps as a short term solution.
- Replace lifted section of path, remove tree or trim roots and install articulated joints or root barriers to prevent or delay future lifting. Consult an arborist when trimming roots.
- Grind the raised section of the trip hazard in conjunction with cutting back roots and/or installing root barriers where tree roots are the cause.
- As well as removing invasive trees, repair the pavement, and replace trees with more suitable species with compact root systems further from the path if possible.


'Make safe' treatment using asphalt ramp.


Grinding of path to remove raised trip hazard.


Short section (three panels) replaced to remove damaged path section or trip hazard.



Source: Brisbane City Council, 2008 *Internal Memorandum Progress Report- TripStop Concrete path Jointing System*.

Case Study: Step-faulting in concrete paths

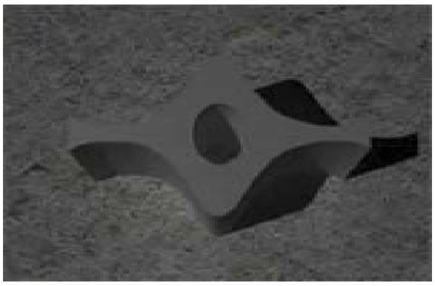
Where step-faulting of the footpath is likely to occur (this may be due to nearby large shrubs and trees), the ideal solution is to isolate the footpath from the roots by placing a 600 mm-deep vertical root-barrier alongside the path, (C&CA, 2006). The alternatives to this are to create some form of sheer connection between slabs that assists in preserving the surface alignment. Traditionally this has been done in thick concrete slabs by using:

- forming devices such as keyed joints, which are restricted to slabs of 100 mm or more in thickness
- dowels, which have large cover requirements and in thin slabs differential movement would cause spalling, or

- continuous reinforcing mesh which again requires cover and likely rusting at the shrinkage cracks.

Brisbane City Council, (BBC, 2008) has been trialing a PVC joint former called 'TripStop' designed to create a rigid, articulated joint between adjoining concrete slabs between 75 and 125 mm thick. It is used in series with a minimum of five consecutive joints installed between the slabs adjacent to the tree as shown below. The additional supply and installation cost of 'TripStop' is around 10 percent of the total path cost but this is likely to be significantly outweighed by the savings derived from extending the life of the path.

Figure 1: The cross-sectional shape of TripStopTM PVC joiners



Path at Location 4 boxed out and ready for installation of 'Tripstop' and concrete.

Path at Location 4 with 'Tripstop' installed and awaiting concrete.

Path at Location 4 with 'Tripstop' installed and awaiting concrete. Note that the top of the joint material in installed flush with the top of the formwork.

Path at Location 4 with 'Tripstop' installed and awaiting concrete. Close-up of holding pin installed to hold joint material in upright position.

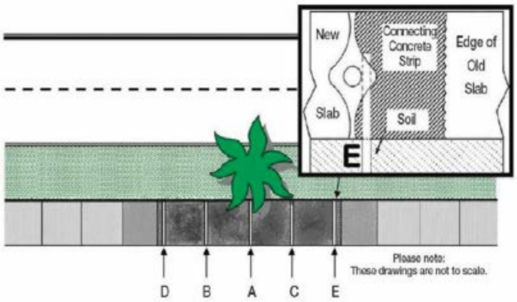
Path at Location 4 with 'Tripstop' installed and after concrete pour to joint. Note that the joint material effectively forms part of formwork.

Finished path at Location 4 with 'Tripstop' installed and after concrete pour. The location of the joints is just visible in the wet concrete.

Installation Guidelines (based on manufacturer recommendations):

- standard footpath/bikepath concrete strength
- non-reinforced sections/paths (i.e. mass concrete)
- minimum of five (5) joints in row (between 4 & 7 panels, depending on join to existing path)
- starting point joint placed, Figure 2 below:
  - over obvious aggressive roots, or
  - where roots not obvious, middle joint on centreline of tree trunk.

Figure 2: 'Tripstop' manufacturer installation requirements.



RMIT University full scale laboratory testing on TripStop (Xie, Setunge & Koay 2005) showed for a 75 mm path thickness only 2.5 mm stepping was recorded with loads in excess of likely design loads and around 4.37 mm was recorded for a 125 mm pavement indicating that they satisfy the AS 3727 requirement of 5 mm.

2.1.5 Cracking

Cracking may occur in any bound pavement material used for a pedestrian and/or bicycle facility. There are numerous causes for cracking including poor edge support, root infiltration, thermal effects, expansion or shrinkage of the sub-grade under the pavement, maintenance vehicles overloading the pavement and bitumen ageing. Narrow cracks may allow water into the sub-base or sub-grade accelerating further deterioration. Wide cracks not only accelerate deterioration of the pavement but also pose a safety risk as bicycle tyres can get caught in them and they can be a catch point and trip hazard for pedestrians.

2.1.5.1 Planning phase

- Adhere to planning maintenance minimisation considerations for vehicle damage issues as this will minimise the potential for cracks to be induced by vehicle traffic (Section 3.4.1).
- Avoid alignments on areas with poor soil characteristic such expansive clays or known issues related to geotechnical stability such as settlement in estuarine areas.
- Where poor soils cannot be avoided pavement type selection should consider continuously reinforced concrete to withstand movement, or a flexible pavement with either a bitumen stone seal or thin asphalt surface that can be repaired easily.
- Edge thickening of concrete paths can reduce edge break of slabs.
- Establish likely pavement loading including maintenance vehicles.

2.1.5.2 Detailed design phase

- Incorporate contraction and expansion joints into the design of concrete pathways at recommended intervals to reduce cracking due to thermal effects and concrete shrinkage.
- Incorporate 600 mm HDPE root barrier along pavement edges (C&CA, 2006) or articulated joint formers at joints where adjacent trees are likely to infiltrate the pavement and cause cracking. Also, install sodium bentonite or similar root growth inhibitor to base of root barrier and at all joints.
- Use a geotextile separating layer as a construction expedient. The geotextile prevents soft ground contaminating the sub-base.
- Edge thickening of concrete paths can reduce edge break of slabs.
- Edge support for asphalt surfaced pavements can be provided to prevent edge break due to vehicular traffic by including concrete edge strips, kerbs or extending underlying the granular pavement well beyond the edge of the asphalt surfacing and providing a compacted granular shoulder of at 0.5 m.
- Ensure correct design loads are identified and used for the pathway design. If maintenance, service or emergency vehicles are likely to cross or travel along the path then these become the design loads. Using correct design loads will ensure the path will not structurally fail in-turn creating surface defects.
- Ensure sufficient drainage cross slopes have been designed to prevent ponding of water on the path surface, damaging the path or allowing water into the sub-base and accelerating deterioration.

- Adhere to detailed design maintenance minimisation considerations for vehicle damage issues (Section 3.4.1), as this will minimise the potential for cracks to occur.
- Should an asphalt surfacing be designed for a concrete pathway, either new or old, ensure that the design includes a bitumen SAMI (strain alleviating membrane interlayer) layer beneath the surfacing to delay reflective cracking.
- Path site stripping of top soil should include grubbing to remove all vegetation including roots from the projected pathway site to prevent weed growth through joints. Consult an arborist for root trimming.
- Specify subgrade compaction and where adequate compaction cannot be achieved require that subgrade improvement or replacement be provided to ensure adequate support for the compaction of the pavement layers.
- Consider geotextile fabric placed on subgrade to prevent weed growth through joints in plain concrete paths.

2.1.5.3 Maintenance phase

- Cracks in asphalt pavements should be filled with hot polymer modified bituminous crack filler, sanded to provide waterproofing and surface friction and finally swept to remove debris.
- Cracks in concrete pavements should be routed and filled with epoxy filler where pavement strength is required to be maintained while a flexible silicone sealant should be used to seal expansion or isolation joints that have opened up.
- A modified binder sprayed reseal may be used to improve the resistance to crack reflection. Paving fabric may also be placed for crack interception and additional waterproofing.
- Where cracks are over 1.5 cm wide or the damage is extensive replace the entire section of path pavement. The cause of the cracking should also be investigated and removed or treated if possible.

	
Cracking in asphalt due to tree roots.	Concrete cracking due to edge loading by vehicles. The cracks have been ground to improve evenness.

2.2 Vegetation and landscape

Refer to the department's *Road Planning and Design Manual* Volume 3, Part 6A for vegetation and maintenance problems.

Additional considerations may include:

- overhanging limbs intruding on pedestrian and cyclists envelopes, (the department's *Road Landscape Manual*, 2013)
- vegetation growth through joints in the path in-turn causing deterioration of the joints
- ponding and damming of storm water on pathways and in bicycle lanes
- a build up of humus facilitating weed growth and encroachment of grasses on the edges of pathways.

Many of these vegetation maintenance issues can be avoided by careful pathway alignment and/or vegetation placement and management. The department's, *Road Landscape Manual*, (2013) has guidance on setbacks and clearances for bicycle ways in Appendix 4.

2.2.1 Pathway alignment

There needs to be careful consideration of the proximity and type of existing vegetation close to the proposed pathway to reduce future maintenance such as trimming, root damage repair and debris removal. The possibility of clearing and removal of adjacent vegetation will be dependent on the proposed path alignment as well as the type, significance and location of the vegetation. In many urban situations planning will involve a vegetation survey and community consultation.

2.2.1.1 Planning phase

- Ensure that pathway is appropriately located in relation to existing vegetation and adheres to all detailed design tolerance levels described in Section 2.2.1.2.
- Contractual agreements should be negotiated with local councils prior to the installation of the pathway for regularly trimming and control vegetation growth at a frequency dependant on the climate and local vegetation.
- Make use of and sculpt from existing trees, rather than planting anew.
- Provide ease of access for mowing/slashing equipment by shaping lawn areas with clean flowing edge-lines and falls.
- Minimise weed growth along fence lines by integrating fence alignments into hardstand areas.
- 1 m run off required by Austroads. Hardstand or turf.
- Maintain sight visibility by accounting for the collective affect of vegetation in areas where bikeways rise, fall and curve.
- Maintain positive surface flows where there is existing vegetation on the low side of a proposed pathway cross-fall to avoid damming of surface water.
- Minimise the need to trim edges by utilising any hardstand areas to function as garden/lawn edging and fence-line mowing strips.
- Limit small, narrow strips of garden or lawn areas which are difficult to maintain by replacing them with hard surface treatments with a surface that contrasts with the path surface material.
- Provide for edge strips on unsurfaced/ granular paths.

2.2.1.2 Detailed design phase

- Design path surfaces to be slightly above ground level to delay the build-up of verge turf.

- Provide hard verges around sign supports to reduce grass cutting/trimming.
- Signs and other objects set back 1m from path to provide clearance.
- 1 m run off required by Austroads. Hardstand or turf.
- Seal path shoulders to adjacent walls or fences where these are closer than 1m to path. This reduces weed growth.
- Design for the preferred minimum canopy clearance for cyclist and shared paths of 3 m, the department's *Road Landscape Manual* (2013) – Appendix 4. Be aware that the branches of many tree species tend to droop when wet.
- Place path edges at least 1.0 m away from the centre of the trunk of all non-frangible vegetation.
- Place path edges 0.5 m or 1/2 Diameter (whichever is greater) to the edge of frangible vegetation.
- Place path at ideally least 10.0 m away from the centre of the trunk of non-frangible vegetation greater than 15 m in height. The distance should be more dependent on the type of tree, in particular whether it has low branches or not.
- Do not use trees which have a reputation of limb drop or large seed/flower drop/deciduous or with known root issues. Where possible set back paths more than 1 m from trees or 1.5 times the mature height or twice the mature canopy width of the tree, (when unsure if non-frangible or frangible). This is to mitigate the risk of trees, limbs, branches and large seeds falling and impacting on pedestrian/ cyclist areas and nodes (e.g. Eucalyptus species). It also reduces the potential for tree root damage and resulting reduction of life to pavement surface by species with known invasive root systems (e.g. Ficus and Melaleuca species).
- Specify the grubbing/ removal of all vegetation from the path pavement footprint to prevent vegetation growth through joints.
- On sections of new path where significant existing problem vegetation cannot be avoided by path placement include 600 mm deep high density polyethylene (HDPE) root barriers along the pavement edge (C&CA, 2006) adjacent to trees for protection from root infiltration. Also install sodium bentonite or similar.

2.2.1.3 Maintenance phase

- Where there is significant reoccurring path maintenance due to the proximity of a path to vegetation consideration should be given to either removing the vegetation or realigning the path. The choice between doing nothing, removing the vegetation and realigning the path should be made after consideration of the cost of each option, any vegetation protection orders and possibly community consultation.

			
Hard surfacing up to wall to remove narrow mowing strip and weed growth.	Narrow strip of grass between path and drain requires mowing.	Isolated small areas of landscaping provided with hard surface to reduce maintenance.	Turf at edge of path should be lower than path as it will prevent path drainage and cause debris build-up.

2.2.2 Vegetation placement

Landscaping of the pathway surroundings can enhance the walking/ riding experience and shield users from adjacent traffic noise and fumes; however, this landscaping should be chosen and placed to ensure that it does not create a future maintenance issue for the path through the generation of debris or damage to the facility. The department's, *Road Landscape Manual*, (2013) has guidance on setbacks and clearances for bicycle ways in Appendix 4.

2.2.2.1 Planning phase

- Minimise complication of construction and maintenance activities by selecting a few proven species and planting them randomly on mass for ease of supply and replacement over time.
- Bushes that will NOT grow tall enough to obstruct sight distances should be planted on the inside of curves.
- Contractual agreements should be negotiated with local councils prior to the installation of the pathway for the regular trimming and control of vegetation growth with the frequency dependant on the climate and local vegetation.
- Minimise pruning of vegetation by selection of species that once mature, 'fit' into the width of corridor to ensure the appropriate riding and walking envelope is maintained at all times in accordance with Austroads guidelines, including the 3 metre recommended canopy clearance height in accordance with the department's *Road Landscape Manual*.
- Minimise maintenance by maximising the use of medium to large shrubs wherever possible. This will provide maximum ground area being shaded to reduce weed growth and erosion with fewer plants per square meter and lower costs to install and maintain.
- Maintain positive surface flows where there is existing vegetation on the low side of a proposed pathway cross-fall to avoid damming of surface water.
- Minimise the need to trim edges by utilising hardstand areas to function as garden/lawn edging and fence-line mowing strips.

2.2.2.2 Detailed design phase

- Locate trees away from critical points on bicycle routes (bends, turns, bus stops).
- Choose evergreen trees/bushes to reduce the accumulation of debris on the pathway.

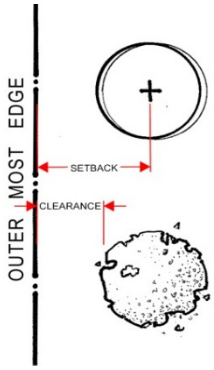
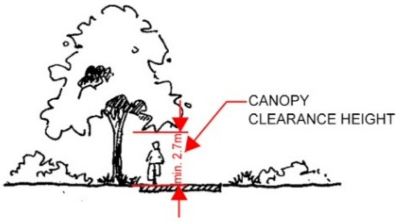
- Design for the preferred minimum canopy clearance for cyclist and shared paths of 3 metres, (Transport and Main Roads 2013).
- Place path edges at least 1.0 metre away from the edge of the mature trunk of all non-frangible vegetation.
- Place path edges 0.5 metres or 1/2 Diameter (whichever is greater) to the edge of frangible vegetation.
- Place path at least 10.0 metres away from the centre of the trunk of non-frangible vegetation greater than 15 metres in height.
- Specify the grubbing /removal of all vegetation from the path pavement footprint to prevent vegetation growth through joints.
- Non-frangible vegetation > 15 metres in height to be set back 10.0 metres from the path.
- Where possible set trees more than 1 metre from the path (to allow shade) or 1.5 times the mature height or twice the mature canopy width of the tree, (when unsure if non-frangible or frangible), Refer to *Guide to Bikeway Pavement Design Construction* and *Maintenance for South Australia - Transport Services Division, 2011*.
- Plant selection should be based on suitability to local climate, soils, rainfall and temperature.
- Specify minimum setback distances from pathways for herbaceous plants based on plant diameter at maturity.
- Specify soil media and mulches free of weed seeds and vegetative matter to avoid contamination of landscaped areas.
- Do not use plants with thorns in landscaping adjacent to paths to reduce the risk of tire punctures.
- Do not use plants with round seeds or hard round fruit (i.e. Quandong) in landscaping adjacent to paths to reduce the risk of crashes.
- Do not use deciduous trees or trees with large flower drop.
- Do not use climbing/trailing plants next to the path.
- Minimise hazards, pruning and damage to tree stock by specifying stock that has been grown/pruned specifically to accommodate branch clearances in accordance with the department's *Road Landscape Manual* and Austroads cycling and waking envelopes.

2.2.2.3 Maintenance phase

- Inspect for and deal with weed infestations such as Siratro early to limit their spread, particularly on the handover of new construction.
- Program regular sweeping and mowing routines with increased frequency of mechanical sweeping during the high growth periods and autumn and early winter in areas where there is deciduous vegetation.
- Undertake inspections to assess effectiveness of sweeping.
- Control growth of trees, shrubs and vegetation with particular attention to bends, turns, and transitions.

- Trimming of trees, grass, overhanging branches and shrubs to maintain safe clearances (riding envelope) and sight distances.
- Include the bicycle paths in weed spraying programs, concentrating on the edge of the path, weeds in joints and weed growth in landscaped areas and sight lines.
- Spray and remove weeds that have thorns or spiked seeds such as Calthrop and prickly weeds that could puncture bicycle tires.
- Program vegetation inspection and trimming.
- Cut back vegetation to the trunk to prevent encroachment.
- Ensure that land owners and authorities control vegetation to ensure the appropriate riding and walking envelope is maintained in accordance with Austroads guidelines and a 2.7 metres minimum or the 3 metres recommended canopy clearance height in accordance with the department’s *Road Landscape Manual*.
- Trim back vegetation to allow 1 m clearance between the edge of the path pavement and the vegetation.
- Where verge grass stops water draining from the path grade off to restore drainage path.
- Ensure path is swept clean after vegetation maintenance close to the path.

			
Inappropriate vegetation planted too close to path.	Avenue of trees needed to be planted further from path.	Overhanging vegetation needs constant trimming.	Even grass like vegetation planted too close to a path can be a hazard and reduce operating space.

		
Vegetation encroachment across path.	Illustration of the difference between setback and clearance.	Recommended canopy clearance height is 3 metres and minimum is 2.7 metres for cycleways.

2.3 Associated facilities

Modern pedestrian and bicycle infrastructure includes a growing range of associated facilities which require maintenance such as markings, signs, lighting, counters, vehicle control barriers, and services.

2.3.1 Pavement markings

Pavement markings deteriorate due to neglect, debris accumulation, water damage, ultraviolet light, traffic and vandalism. Road line visibility is an important contributor to the legibility of a design and worn markings will be less visible in the dark and in wet conditions, (National Transport Authority Ireland, 2011). Deterioration of markings is also hazardous due to the increased chance of collision between cyclists and pedestrians, other cyclists or vehicles.

Pavement markings which include glass beads can have reduced wet surface friction. The department's *Guide to Pavement Markings*, sets out markings required for on-road bicycle facilities and discusses the preferred marking materials. The department's *Traffic and Road Use Management Manual* Volume 1, Chapter 34, Coloured surface treatment for bicycle lanes provides guidance on the use of green coloured surface treatments for bicycle lanes. The treatment was endorsed by the Queensland Traffic Management Practices Committee (TMPC) in Main Roads on 13 March 2003. It outlines why, when and where coloured surfaces should be used on cycle facilities based on a scored warrant system.

2.3.1.1 Planning phase

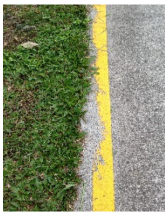
- Ensure that vegetation will not contribute to debris which can cover pavement markings on paths by adhering to all planning maintenance minimisation considerations for vegetation control (Section 2.2).
- Ensure ponding/standing water does not cover markings on the path in accordance with drainage issue minimisation considerations (Subsection 2.1.2).
- Adhere to planning maintenance minimisation considerations for vandalism issues as this will minimise the potential for vandalism of markings (Subsection 2.4.2).
- There is a need to be aware that thermoplastic lines have a tendency to delaminate, break up and litter the roadway. Line markers need to properly prepare the surface to minimize the risk that the paint or thermoplastic does not stick correctly and come off prematurely.

2.3.1.2 Detailed design phase

- Use durable and high quality products for markings on paths in accordance with departmental specifications and approved supplier lists.
- Require that the road surface on which green epoxy resin is to be applied is in good condition, dry, free of oil and dirt, and have sufficient texture as these products tend to delaminate early if the surface is not adequately prepared.
- Consider use of quality thermoplastic line markings as they last longer than paint in most circumstances and thus reduce maintenance.
- Thermoplastic markings should have chamfered edges to improve ride quality for cyclists and a gritted surface to improve friction.
- Select marking materials that do not become slippery when wet.

2.3.1.3 Maintenance phase

- Establish a regular inspection schedule and undertake programmed and reactive maintenance of markings.
- Surface markings including symbols should be renewed when legibility becomes poor, ensuring that the pavement surface is clean before application.
- Replace marking if they are damaged during pavement maintenance.

			
Pavement markings damaged by vehicle traffic.	Lines need to be reinstated after maintenance.	Delamination of an epoxy surface colour.	Mow edges and clean path before line marking.

2.3.2 Utility and services

Utility and service access covers and pits that are not installed or maintained properly pose a major safety issue for pedestrians and cyclists. They pose the risks of tripping hazards, slippery surfaces and potential for catching bicycle wheels. Service pits generally can only be raised or repositioned by the asset owner which adds considerable time and cost to the installation of a pathway.

The issues that arise from poorly located gullies and lids are that gully slots run parallel to bicycle wheel tracks, and differential settlement, poor placement of covers and poor installation and construction of service covers that fail cause surface unevenness. Pits located in concrete pavements often result in unplanned cracks radiating from the corners of the pit and odd shaped slabs around the pit that crack and become uneven.

Where services are located under or adjacent to pathways their maintenance may involve excavation of the pathway and the later settlement of patches that cause unevenness and a change in path surface.

Minimum vegetation setbacks for underground services and pits are contained in department's *Road Landscape Manual* (2013), Appendix 4.

2.3.2.1 Planning phase

- Consider locations and accesses of existing infrastructure located under or near the proposed path location and separate pathways and services if possible.
- Position service access lids away from bicycle and pedestrian routes, particularly from bends.
- Check with councils during the planning stage for proposed developments that may be scheduled to take place near the proposed facility as these may require new utility access points at a later date.
- A setback distance of 1.0 metres between service access covers and vegetation with a mature height less than 3.5 metres, is to be applied to ensure maintenance access to pits and inspection points.
- A setback distance of 4.0 metres between underground services and vegetation with a mature height greater than 3.5 metres is to be applied to ensure tree roots do not impact on underground infrastructure. This setback will vary with species characteristics; that is, greater setbacks are required for species with vigorous growth or that are known to have invasive root systems.

2.3.2.2 Detailed design phase

- Specify that recessed manhole lids must be finished in a surface layer material that matches the friction provided by the path.
- Concrete infill lids are likely to provide more durable friction supply compared to lids with painted surface treatments.
- Choose side draining gullies/kerb arrangements in preference to channel located gullies. Choose flat grill gullies in preference to slotted gullies.
- Restrict the use of steel plates on paths or roads. A high friction surface treatment must be applied to steel plates even where they are used temporarily and ensure a smooth transition from existing road through the plate and back to the original surface again. Include warning signs to slow users when approaching such temporary measures.
- Bicycle safe grates conforming to AS 3996 shall be used e.g. grates and grills 90 degrees to the bicycle wheel and grates that will not cause bicycle wheels to become trapped.
- Provide joint patterns around service pits that reduce unplanned cracking by installing an isolation joint around the pit and starting crack control joints from corners in preference to sides, and/or reinforce the slab containing the service pit, tying the upper steel edge of the pit into the reinforcing.

2.3.2.3 Maintenance phase

- Inspect service access points as part of routine/programmed inspections.
- Re-set broken, loose or poorly aligned gullies or manhole covers or lids as required.
- Ensure that service access points are raised as part of path or on –road lane overlay to maintain evenness.

- Reset catch basin grates flush with pavement.
- Replace sections of path completely and relocate service accesses in dangerous, highly used sections or problematic areas that have ongoing safety or maintenance issues.
- Encourage the service owners to restore the path after trenching across it to:
  - provide adequate compaction for the full depth of the filled trench
  - replace the complete slab on a concrete path with a matching concrete slab or
  - patch an asphalt path with compacted hot mix asphalt to match the existing.

			
Service pits create odd shaped slabs which are prone to cracking and a variety of surfaces some of which can be slippery when wet.	Ideally service pits should be located off the path.	Poor service trench reinstatement causing uneven surface.	Settlement around service pits can create unevenness and trip or wheel trap hazards.

			
Gap in steel covers on service trench could trap bicycle wheel and are slippery when wet.	Cracks radiating from corners of pit can be designed out by jointing from corners.	Concrete infill lids are preferred to steel lids.	Trench repairs often require ongoing maintenance better to replace slab.

2.3.3 Lighting

Lighting is an important element for pedestrian and bicycle facilities for personal safety issues such as criminal attacks, pedestrian and cyclist collisions and cyclist crashes due to poor visibility. The maintenance issues relating to lighting include bulbs failure, vandalism, poor lighting products initially installed, poor placement of lighting structures, damage to structures and hazardous positioning of lighting structures.

2.3.3.1 Planning phase

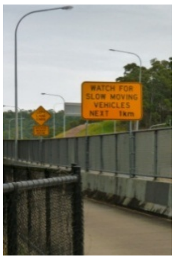
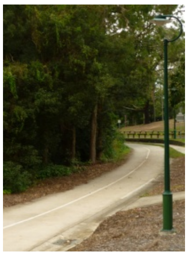
- Minimise the need for maintenance of lighting fixtures/structures by choosing high quality products.
- Ensure lighting is of sufficient quality and intensity to illuminate cyclist's path.
- Ensure lights are shielded sufficiently so that they don't shine unnecessarily into people's windows, as this can result in complaints and resistance to lighting on other pathways.
- Set back trees from the line of street lights - do not plant trees within 10 metres (or outside illumination zone) of the front of the lighting assembly.
- Consider placing lighting columns in verges to facilitate bulb changes.

2.3.3.2 Detailed design phase

- Where the cyclist/pedestrian facility is located alongside an existing road that is lit, consider integration of lighting into the existing to reduce the number of poles and power costs.
- Concrete paths are more visible in low light.
- Incorporate concrete edges or edge lines into the design of asphalt paths as this is helpful for cyclists in low light conditions.
- Consider additional lighting fixtures such as solar powered illuminated pavement markers where paths change in direction, especially on bicycle paths.
- Set back trees from the line of street lights and choose shorter trees / bushes to minimise shadows.
- Specify lighting equipment from the department's Intelligent Transport Systems and Electrical Approved Products and Suppliers list.
- Ensure lighting poles do not encroach into pedestrian or cyclist envelopes.
- Screen adjacent properties from unwanted light.

2.3.3.3 Maintenance phase

- Include bicycle routes as priority routes for lighting inspections.
- Prioritise lighting inspections on collector routes, where there are higher traffic speeds and volumes, in curves or bends, in dangerous areas.
- Based on inspection, cut back encroaching trees at known points that shield paths from the light sources.
- Undertake reactive maintenance for replacing broken or damaged bulbs in accordance with inspections.
- Replace or repair of broken or damaged lighting structures.
- Establish a cyclic lamp replacement program to reduce outages and call out costs.
- Inspect electrical wiring components at six yearly intervals or as required.
- Insect columns for corrosion/damage at six yearly intervals.
- Replace diffusers every fifteen years.

	 
Utilise spillover from adjacent road lighting wherever possible	Setback lighting from path edge.

2.3.4 Signage

Cycle way signage deteriorates due to ageing, traffic accidents, debris, storms, ultraviolet light and vandalism. Deterioration of signage reduces its effectiveness to warn pedestrians and cyclists of hazards which can create a safety issue. Also, be aware that the absence of effective directional signage can lead cyclists into hazardous areas. The department's *Manual of Uniform Traffic Control Devices* Part 9- Bicycle Facilities details regulatory sign treatments for on-road and off-road bicycle facilities. Guide and warning signage are set out in the department's *Traffic and Road Use Management Manual* Volume 1, Chapter 36. Queensland Cycle Network Directional Signage Guidelines.

2.3.4.1 Planning phase

- Ensure that signs will not be exposed to deterioration from vegetation by adhering to all planning maintenance minimisation considerations for vegetation control (Section 2.2).
- Ensure that vegetation will not cover signage on paths by adhering to all planning maintenance minimisation considerations for vegetation control (Section 2.2).
- Ensure that signs do not become obstructions in relation to a pathway or a safety hazard to cyclists by creating sufficient horizontal and vertical clearance from the path, minimum setback of 1 m.
- Ensure a minimum height of 2.5 m is specified for signs to prevent the signs becoming easy targets for graffiti.
- Adhere to planning maintenance minimisation considerations for vandalism issues as this will minimise the potential for vandalism of signs (Subsection 2.4.2).
- Maximise visibility to signage. Do not plant large plants within an area 75 metres long directly in front of road signage, or choose plants that will not grow high enough to hide the sign.

2.3.4.2 Detailed design phase

- Use durable and high quality products for signs from the approved supplier list for Traffic Engineering and Road Safety Approved Products- Retro-reflective Sheeting Material.
- Use rotation resistant fixings on all free standing signs.
- Consider flexible sign supports where signage is located in situations known to be regularly damaged by errant vehicles (e.g. KEEP LEFT signage on refuge islands), as damaged poles can be a spearing hazard to cyclists and motorcyclists.

- Harden verges locally close to sign support structures to reduce grass cutting, Transport and Main Roads, 2005.
- Adhere to detailed design maintenance minimisation considerations for vegetation issues as they will minimise deterioration and maximise visibility of signs (Section 2.2).
- Adhere to detailed design maintenance minimisation considerations for vandalism issues as this will minimise damage to and maximise visibility of signs (Section 2.4.2).

2.3.4.3 Maintenance phase

- Establish a regular inspection schedule and undertake programmed and reactive maintenance of signage.
- Clean, repair or replace defective or damaged signs immediately after inspections.
- Consider replacing rigid steel poles with flexible sign supports where signage is regularly damaged by errant vehicles (e.g. KEEP LEFT signage on refuge islands), as damaged poles can be a spearing hazard to cyclists and motorcyclists.
- Clean, repair or replace vandalised signs, dependent on severity of damage.

Setback sign posts a safe distance.

2.3.5 Bridges

Bridge decks and their surfacing, as they deteriorate, develop rough or slippery surfaces or gaps in the deck particularly when made of timber. There can also be alignment issues with ramps and barriers on the approaches that are hazardous to users.

The department currently has a number of different types of structures on the bicycle network constructed with a variety of materials, all of which require on-going maintenance. As these structures tend to have common components the department's *Bridge/Culvert Servicing Manual* (Main Roads, 2008) contains a set of standardised servicing requirements that have been prepared for the following component groups:

- Deck Surface
- Bridge Substructure
- Bridge Superstructure
- Timber Bridges
- Culverts
- Guardrail and Bridge Rail
- Sign and Delineation
- Waterway

- Approach Embankment.

These servicing requirements include both preventative as well as reactive maintenance items that need to be followed to ensure future maintenance is minimised.

2.3.5.1 Planning phase

- Align the facility in relation to existing bridges ensuring a smooth transition.
- Examine alternative material types with a view to minimising maintenance when planning bridge structures.
- Where hydraulic and economic considerations allow plan for a culvert in preference to a bridge.
- Decide if the bridge is to carry vehicles and define the design loading.

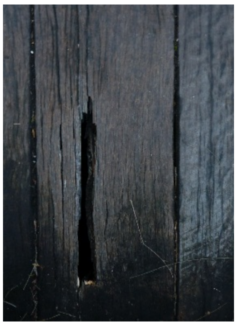
2.3.5.2 Detailed design phase

- Ensure pathways are attached flush to bridges via the use of the department's Standard Drawings.
- Install bicycle friendly ramp approaches from pathways to bridges for easier transition.
- Install warning signs if transitions include a sharp turn, or steep slope.
- Follow standard drawings and design procedures outlined by the department for kerb ramps and guardrail placement.
- Ensure all expansion joints are sufficiently sealed and joints are flush.
- Ensure bridge design allows for easy inspection of structural components including any bearings.
- Select durable, low maintenance materials for bridge design, e.g. concrete and/or galvanised steel.
- Ensure design loads reflect the intended use and that over loads from vehicles are physically excluded if possible.
- When detailing access control devices for use on bridges use elements/materials that will not rust.

2.3.5.3 Maintenance phase

- Observe the requirements of the department's *Bridge/Culvert Servicing Manual* (Main Roads, 2008).
- Cover bridge surface material in poor condition such as timber planks in asphalt or appropriate non slip surface material. The type of existing structure may determine if concrete or asphalt may or may not be used for resurfacing depending on the allowable dead load.
- Ramp trip hazards at pedestrian and bicycle facilities connections to bridges as a temporary measure.
- Grind any concrete trip hazards but not where structural reinforcing steel is likely to be uncovered.
- Ensure bitumen ridges at expansion joints are regularly ground flush.

- Replace existing failed joints.
- Prioritise bridge inspections on pedestrian and bicycle routes, paying particular attention to decks, deck drainage, barriers, ramps and joints.
- Clean off and paint rusting steel components as early as possible to minimise structural damage.
- Trim vegetation back from bridge to allow easy access for inspection and maintenance and prevent fire damage.
- Establish that maintenance vehicles will not overload bridge structure before use.
- Carry out routine maintenance to ensure internal mechanisms of bollards do not rust or seize.
- Clean bridge deck drainage including scuppers and clear dirt from decking.
- Resurfacing of a timber deck with asphalt only if the structure can support the additional dead load.
- Repair any gaps in timber decking that could trap bicycle wheels.
- Do not use concrete or bitumen ridges to direct storm water off the road.

			
Joint in bridge deck needs resealing.	Timber kerb and deck damaged by guardrail displacement.	Temporary plywood repair to timber deck.	Gap in decking due to wood rot.

2.4 Facility management

2.4.1 Vehicle access management

Vehicle damage refers to the deterioration and failure of pedestrian and bicycle facilities due to loading or impact by vehicles such as maintenance and emergency vehicles. Often maintenance vehicles such as mowing support trucks or tractor slashers are the cause of pavement damage. This can result in safety issues for cyclists and pedestrians due to cracking, sub-base failure and missing sections of the facility at points where the vehicles cross or drive along a path. Maintenance vehicles must have access to bicycle facilities so that maintenance can be performed efficiently and this should be catered for in the planning and design.

2.4.1.1 Planning phase

- Limit the types of vehicles that may access the path through design and by installing regulatory signs.

- Plan for adequate width and access points so maintenance vehicles may enter and exit path corridors without damaging the facility.
- Determine what types of vehicles will be using the path during and after construction.
- Identify points of access that are convenient and easily traversed by maintenance and service vehicles.
- Provide regular shapes of the surrounding environment to allow proper grass cutting by mowers.
- Provide ease of access for mowing/slashing equipment by shaping lawn areas with clean flowing edge-lines and safe slopes. A slope of 1 in 4 is traversable by mechanised maintenance. Steeper slopes require maintenance by people using hand tools. Slopes steeper than 1 in 2 should be considered un-maintainable and be treated with low maintenance plantings.

2.4.1.2 Detailed design phase

- Ensure correct design loads are used for the pathway. Using correct design loads will ensure that the path will not structurally fail and result in surface defects.
- Limit inadvertent public vehicle access with control devices only if usage by private vehicles is considered likely and infrastructure such as lightweight bridges might collapse under vehicle loading. Access control devices such as bollards and deflection rails are a safety hazard to path users and limit path capacity. When in doubt leave access control devices out.
- Specify adequate compaction of sub-grade and pavement materials.
- Ensure that adequate widths and access points are available for maintenance vehicles.
- Locate access points that convenient for maintenance personnel, and easily traversed by maintenance and service vehicles, and minimize the need for vehicles to cross pathways.
- Where vehicles are likely to cross the path create a crossings point with stronger pavement design.
- When detailing bollards, gates or banana bars use elements/materials that will not rust.

2.4.1.3 Maintenance phase

- Enforce and prevent unauthorized vehicles from using path.
- If unauthorized access is an ongoing issue, establish access controls such as garden beds, fences, bollards or deflection rails. Access management should be located on straight sections of path.
- Repair any damage caused by maintenance vehicles as soon as possible after the time of damage if possible. Immediately provide signs and barriers to protect cyclists and pedestrians from hazardous situations that result from the damage.
- Use a regular inspection schedule to check for damage caused by vehicles after maintenance has been undertaken.
- Regularly maintain fences and access gate fixtures and fittings to ensure consistent and reliable operation.

- Postpone maintenance using heavy equipment after heavy rain to allow the ground to dry out and properly support the path.
- Where possible drive on the grass instead of the path. Grass is easier and cheaper to repair than damaged path.

Public vehicle access to path is limited by banana bars while a slide rail gate is provided for maintenance vehicles.

2.4.2 Vandalism

Vandalism of pedestrian and bicycle facilities can lead to broken or damaged signs and lighting structures, accumulation of debris on the pavement and visually unappealing paths. Vandalism is often facilitated by poor or concealed placement of facilities. Concealed locations allow vandals to damage facilities without being noticed by the public. Vandalised routes can limit path patronage by making legitimate users feel insecure; the path is then avoided by users allowing further vandalism to occur unchecked. This downward spiral is known as "The broken windows theory".

2.4.2.1 Planning phase

- Adhere to the design principles from published in the *Queensland Government Crime Prevention Through Environmental Design – Guidelines for Queensland*, Part A – Essential Features for Safer Places. Also refer to the *Road Landscape Manual* Safety chapter.
- Ensure that minimum sign heights of 2.5 metres are specified as signs that are hung too low are easy targets for graffiti.
- Maximise visibility of pathway by the general public where possible.
- Locate paths so that they are overlooked from open space.

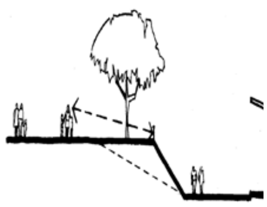
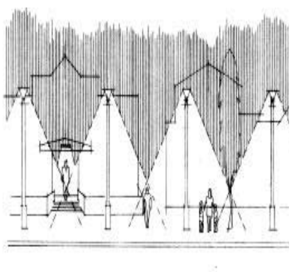
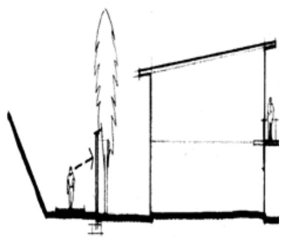
- Define use and ownership of paths by erecting barriers such as fences or vegetation but do not conceal the paths from public view.
- Avoid areas which have poor surveillance and concealed access routes.
- Adopt neighborhood and centre urban design layouts which do not separate pedestrian/cyclist routes from the street network.
- Consider providing facilities to encourage legitimate usage. E.g. seating, play equipment, circuit training equipment, skate/bmx /terrain park facilities, legal street art walls.
- Avoid creating narrow paths hidden from view behind fencing or at the rear of buildings.

2.4.2.2 Detailed design phase

- Design paths to minimise sudden changes of grade and blind corners.
- Design landscapes to minimise interference with sightlines and create hidden areas.
- Use durable and high quality products for path signs and markings that are graffiti resistant.
- Consider using landscaping to reduce the appeal of surfaces for graffiti. (E.g. shrubs, creepers).
- Provide rotation resistant fixings for all new signs.

2.4.2.3 Maintenance phase

- Inspect path for vandalism.
- Clean or paint out graffitied sections of path without compromising path surface friction.
- Replace broken structures or signs.

			
Avoid sharp changes in grade.	Design landscape to minimise interference with sight lines.	Provide sufficient lighting.	Do not locate paths in areas with poor surveillance and predictable root migration.

Source: Crime Prevention through Environmental Design (CPTED) Planning Scheme Policy

	 	 	
Sign/map needs cleaning with suitable solvent.	Graffiti on path should be removed promptly to discourage additional vandalism.	Graffiti on walls needs to be painted out or removed promptly.	Walls and signs are often targets.

2.4.3 Debris

Refer to the department's *Road Planning & Design Manual* Volume 3, Part 6A for debris and maintenance considerations for paths.

Some debris may be seasonal (e.g. Jacaranda flower litter) or be more event based (e.g. storm events, or broken glass after large public events such as firework displays, football grand finals etc.).

Erosion is an issue that affects pedestrians and bicycle facilities located next to steep terrain or where the landscape has been excavated to accommodate new infrastructure. In such terrain well designed batters and drainage is required to minimise erosion and deposition on the path.

2.4.3.1 Planning phase

- Locating the pathway further from vegetation, waterways, shops and highly populated pedestrian areas such as bus stops or with appropriate buffer zones will reduce the accumulation of litter and debris.
- Contractual agreements for programmed and reactive clearing of debris on the facility (e.g. mechanical sweeping) should be set in place with local councils prior to the installation of the pathway.
- Check with councils during the planning stage for proposed developments that may be scheduled to take place near the proposed facility and which may create potential debris.
- Consider the need for litter bins given likely path usage and adjacent land use.
- Locate bus shelters a distance from pedestrian and bicycle facility including on-road bicycle facilities where possible.
- Adhere to planning maintenance minimisation considerations for vegetation issues as this will minimise debris caused by vegetation (Section 2.2).
- Provide adequate clearance between paths and the toe of batters so that material (e.g. litter, mulch, soil) does not wash onto paths during rain storms.

2.4.3.2 Detailed design phase

- Choose pavement surface materials that minimise debris as they age in high use areas. Concrete - will provide the hardest most durable surface with the longest lifespan but comes with higher construction costs. Asphalt is more susceptible to produce debris (e.g. loose stones) and requires maintenance to maintain a smooth surface. Granular (unsurfaced) paths will produce the most amount of debris and requires regular maintenance to keep a consistent surface as well as being prone to washouts, rutting and erosion.
- Ensure the quality, strength and durability of chosen materials by specifying the standard materials and suppliers from the Transport and Main Roads Standard Specifications where appropriate.
- Design path pavements for correct design loads including maintenance vehicles.
- Specify failure reinstatement standards using non-granular material where possible.
- Design barriers or fences to stop falling rocks and debris from migrating onto paths where the pathway is located next to steep slopes and embankments.
- Require kerbing on the path edge at the base of steep slopes.
- Adhere to detailed design maintenance minimisation considerations for vegetation issues as this will minimise debris caused by vegetation (Section 2.2).
- Consider the best locations of litter bins to promote use by users and ease of litter collection; recommended bin placement locations include seating nodes, shelters, vista points, amenity blocks, carparks, in close proximity to food outlets and areas where other maintenance is required.
- Ensure adequate drainage of the path and surrounding area to eliminate waterborne debris accumulation, and avoid inundation from flow paths crossing path surfaces.
- Reduce the presence of loose gravel on roadway shoulders by paving adjoining accesses.

2.4.3.3 Maintenance phase

- Establish a regular sweeping schedule for routine, reactive and special sweeping needs (e.g. high debris areas such as adjacent to food or liquor outlets. Give particular attention to bends, turns, transitions, and bus stops.)
- Mechanically sweep paths during and after maintenance has been undertaken on the pathway, adjacent vegetation or infrastructure next to the pathway.
- Ensure roadway sweeping regimes extend to the very edge of roads containing on-road bicycle lanes, and ensure that debris is not swept into shoulder gullies.
- Undertake inspections to assess effectiveness of routine sweeping regimes.
- Provide additional bins where litter is a continuing problem.
- Undertake inspections following storm events for debris or fallen vegetation.
- Reduce the presence of loose gravel on roadway shoulders by sealing adjoining accesses.
- Grade back verge in areas where water borne debris is deposited on the path to improve drainage and encourage deposition away from path.

			
Debris on path from high tide.	Sand from adjacent play ground covering path.	Park runoff depositing debris on path.	Litter from road will wash on to path in next storm and should be picked up.


Debris from vegetation maintenance left in drain.

2.4.4 Preventative maintenance

The department has its maintenance work for assets including pedestrian and cycleways divided into three programs:

- Routine maintenance – reactive and cyclic interventions to repair damage, maintain safety, prevent further damage from deterioration and maintain amenity and appearance.
- Program maintenance – primarily the resurfacing of bituminous pavement on a cyclic basis at around 10 to 15 years depending on the type of surface.
- Rehabilitation – the refurbishment of the facility at the end of life of major components such as the pavement by overlay or reconstruction at around 20 to 40 years.

These maintenance programs are interdependent. The cycle of program maintenance and rehabilitation can be extended considerably by timely routine maintenance including repairs such a pothole patching crack sealing, and cyclic activities such as inspections, vegetation control, drainage cleaning and repair. In order to gain maximum benefit from routine maintenance as well as fixing the damage, the underlying cause of the damage usually needs to be addressed to prevent reoccurrence and further routine maintenance in the same location.

Integrating routine maintenance of pedestrian and bicycle facilities into contracts for associated road facilities is one way for bicycle facility owners to ensure that routine reactive and minor preventative maintenance is not forgotten. Stand-alone facilities may warrant a separate maintenance contract or they can be appended to the list of roads to be maintained in an existing contract.

Regular inspections, timely repairs and programmed maintenance are required to minimize life cycle maintenance costs.

The most effective way to plan for pedestrian and cycleway asset maintenance and renewal over the long term at minimum cost is to include them in the department's asset management systems and prepare a comprehensive asset management plan for them.

2.4.4.1 Inspections and defect reporting

Bicycle path routine maintenance programs should include cyclic inspections of the facility to report any deficiency and generate a schedule of repairs for prioritisation and resourcing. In addition, inspections should be carried out after storms and flooding which are likely to create debris on the path or in drainage structures or other damage to the facility or associated vegetation. Bridge, major culvert and electrical specialist inspection programs also need to be conducted at the required frequencies to ensure the safety of the facilities.

Signage indicating an e-mail address or hotline for defect reporting should also be considered.

2.4.4.2 Timely repairs

Regular maintenance activities on paths and lanes should include:

- filling of pavement cracks and potholes
- milling or asphalt ramping of steps in the pavement at joints or cracks
- trimming or removal of grass so that it does not intrude into the path
- sweeping of paths to remove debris such as broken glass and fine gravel (including that arising from construction and maintenance activities such as crack sealing)
- re-painting of pavement markings
- cleaning of signs
- restoration of vandalized facilities
- trimming of trees and shrubs to maintain safe clearances and sight lines
- patching of pavement surface to reinstate waterproofing, and
- root control.

2.4.4.3 Programmed maintenance

Bitumen oxidises and shrinks over time, resulting in cracks and/or ravelling of the bituminous pavement surface. Thus timely resurfacing of bitumen pavements will maintain waterproofing and minimize water related damage to the structural pavement layer and debris (i.e. loose stones, gravel and soil). This periodic resurfacing by overlay or mill and overlay is categorised as Programmed Maintenance by the department and is essential to ensure the long term integrity of the facility. With concrete pavements, sealed expansion joints should be resealed on a regular basis and any unplanned cracking repaired as it occurs.

For further information on this Technical Note, please contact:

Mark McDonald
Transport and Main Roads – Engineering & Technology Branch
Phone: (07) 3066 6494 Email: mark.d.mcdonald@tmr.qld.gov.au

3 References

ARRB Group 2013, Information and Agency Review – *Maintenance Minimisation Practices and Principles for Walking and Cycling Facilities*, Contract Report – 006573, Victoria, Australia

Engineers Australia, 2010, *Infrastructure Report Card 2010*, Queensland Transport Energy Water Telecommunications, Engineers Australia, October 2010, Brisbane, Queensland, Australia.

Australian Government: Department of Infrastructure, Transport, Regional Development and Local Government, 2006, *User guide to bicycle and shared path selection – Using whole-of-life costing*, by ARRB Group, WC5226-III, Sydney, Australia.

Austroads, 2009a, *Guide to Pavement Technology*, Part 5: Pavement Evaluation and Treatment Design AGPT 05-09, Austroads incorporated, Sydney, NSW, Australia.

Austroads, 2009b, *Guide to Pavement Technology* Part 7: Pavement Maintenance, AGPT07-09, Austroads incorporated, Sydney, NSW, Australia

Austroads 2009c, *Guide to Pavement Technology* Part 6: Unsealed Pavements AGPT06-09, Austroads incorporated, Sydney, NSW, Australia

Cement and Concrete Association of Australia, 2006 *Guide to Residential Streets and Paths*, C&CAA 2006, Sydney, NSW, Australia.

Transport and Main Roads, 2010, *Road Drainage Manual*, Transport and Main Roads, Brisbane, QLD, Australia.

Transport and Main Roads, 2005, *Designing For Maintenance*, Interim Advice TMR 2005 Brisbane, QLD, Australia.

Transport and Main Roads, 2013, *Road Landscape Manual*, Transport and Main Roads, Brisbane, QLD, Australia.

South Australian Department of Transport, 2011, *Guide to Bikeway Pavement Design Construction and Maintenance for South Australia* - Transport Services Division, Adelaide, SA, 2011.

Caltrans, 2006, *Highway Design Manual* Chapter 1000, Bikeway Planning and Design, California Department of transport, California, United States of America.

Brisbane City Council, 2008 I*nternal Memorandum Progress Report- Tripstop Concrete path Jointing System*.

Y.M. Xie, S. Setunge, Y.C.Koay, School of Civil and Chemical Engineering RMIT University, 2005, *Report on full scale laboratory tests on TripStop PVC joiners for concrete footpath of 75 mm thickness*, Melbourne, Australia

Y.M. Xie, S. Setunge, Y.C.Koay, School of Civil and Chemical Engineering RMIT University, 2005, *Report on full scale laboratory tests on TripStop PVC joiners for concrete footpath of 125 mm thickness*, Melbourne, Australia

Standards Australia, *Australian Standard AS3727: Guide to Residential Pavements*, 1993.

National Transport Authority 2011, *National Cycle Manual*: Part 6 - Maintenance, Ireland

Transport and Main Roads, *Traffic and Road Use Management Manual* Volume 1 Chapter 34 Coloured surface treatment for bicycle lanes: August 2010, Transport and Main Roads, Brisbane, QLD, Australia.

Transport and Main Roads, 2001, *Guide to Pavement Markings*, Transport and Main Roads, Brisbane, QLD, Australia.

Standards Australia, *Australian Standard AS 3996: Access covers and grates*, 2006.

Transport and Main Roads, Intelligent Transport Systems and Electrical Approved Products and Suppliers list. http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Approved-products-and-suppliers/Intelligent-transport-systems-and-electrical-approved-products-and-suppliers.aspx

Queensland Government, 2011, *Manual of Uniform Traffic Control Devices* Part 9- Bicycle Facilities, 2003 Second Issue, 2 April 2011, Brisbane, QLD, Australia.

Transport and Main Roads, *Traffic and Road Use Management Manual* Volume 1 Chapter 36. Queensland Cycle network Directional Signage Guidelines: November 2012, Transport and Main Roads, Brisbane, QLD, Australia.

Queensland Department of Main Roads, 2008, *Bridge/Culvert Servicing Manual* Main Roads, October 2008, Brisbane, QLD, Australia

Queensland Government, *Crime Prevention through Environmental Design – Guidelines for Queensland*, Part A – Essential Features for Safer Places.

Transport and Main Roads, *Road Planning and Design Manual*, Volume 3 Part 6A