Master Specification Guideline

Guide to Bikeway Pavement Design, Construction & Maintenance for South Australia

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Foreword

The purpose of this Guide is to present general information and considerations relating to the design, construction and maintenance of bikeway pavement configurations that should generally provide acceptable in-service performance. The Guide is intended for a range of users that includes technical and professional staff in local government, consultants, and experienced pavement specialists within and external to the Department.

Previous revisions of this Guide included advice on selection of pavement design parameters, pavement design calculation procedures, a catalogue of detailed designs, and other content. This content has been moved to Master Specification Part RD-PV-D1 “Pavement Investigation and Design”.

The catalogue of pavement designs present in Revision 1 has been retained. These are provided for information only to illustrate typical design configurations. They are not to be used on Department projects where instead project specific designs must be prepared in accordance with Master Specification Part RD-PV-D1 “Pavement Investigation and Design” requirements. The use of these example designs by others on their project is at their risk as per the disclaimer.

Contents

Guide to Bikeway Pavement Design, Construction & Maintenance for South Australia

1 General

1.1 Introduction

a) Bikeway is a generic term for an off-road exclusive-use path for cyclists or a shared-use path for pedestrians and cyclists and other users of wheeled devices including wheel chairs, scooters and skateboards.

b) Bike lanes on road pavements are not included within this definition.

c) The purpose of this Guide is to provide bikeway designers and asset managers with a basis for designing, constructing, and maintaining bikeway pavement configurations that should generally provide acceptable in-service performance.

d) Specific design guidance on mandatory minimum design requirements for Department projects is provided in the Master Specification Part RD-PV-D1 "Pavement Investigation and Design". Previously this content was contained within this Guide, but it was moved to RD-PV-D1 - "Pavement Investigation and Design" to provide consistency in investigation, design and contractual outcomes. The pavement design configurations provided in this Guide are for example only, and project specific pavement designs must be prepared for each Department project in accordance with RD-PV-D1 "Pavement Investigation and Design".

e) The content presented in this Guide has been developed from an expert pavement engineering review and adaptation of Australian and overseas literature on bikeway and lightly trafficked road pavements. References from which designers can obtain more information are also identified.

f) This Guide is arranged in 5 principal parts, as follows:

   i) **General** – presents the scope and purpose of the Guide, typical bikeway types and users, surfacing types and economic considerations;

   ii) **Pavement selection** – defines flexible and rigid pavement types, and the selection criteria and attributes of the normal range of pavements and surfacing;

   iii) **Pavement design guidelines** – discusses the pavement design components of subgrades, pavement materials, and design traffic;

   iv) **Construction** – considers many of the critical construction details and specification requirements of bikeways; and

   v) **Maintenance** – includes monitoring and maintenance activities and techniques, as well as safety issues to be considered when undertaking works.

g) Consideration of planning, strategy and geometric design, traffic engineering and non-pavement related aspects of bikeways are excluded from this Guide as these are comprehensively outlined in:

   i) Austroads Guide to Road Design Part 4: Intersections and Crossings; and

   ii) Austroads Guide to Road Design Part 6A: Paths for Walking and Cycling.

h) Austroads AP-G88-17 Cycling Aspects of Austroads Guides provides a summary of design guidance and criteria relating to on-road and off-road bicycle facilities together with a high level of cross-referencing to the relevant Austroads Guides for further information.

i) The 2024 update of this Guide resulted in transfer of minimum requirements on Department projects to Master Specification Part RD-PV-D1 "Pavement Investigation and Design". RD-PV-D1 "Pavement Investigation and Design" takes precedence over any content contained in this Guide on Department projects, which is more generalised and illustrative of typical design outcomes. A project specific pavement design meeting RD-PV-D1 “Pavement Investigation and Design” requirements must be completed on Department projects.

1.2 Bikeway characteristics

1.2.1 Bikeway types and users

a) There are 3 main types of bikeways:

   i) shared use paths;

   ii) separated paths with delineated pedestrian and cyclist zones; and

   iii) those reserved for the exclusive use of cyclists.

b) Shared use paths (refer Figure 1-1) are the most common type in South Australia and are generally constructed to service a wide range of users:

   i) cyclists – including primary or secondary school children, recreational cyclists, commuter cyclists, touring cyclists, and sports cyclists; and

   ii) pedestrians – comprising children, elderly people, people pushing prams and strollers, various individuals and family groups, people walking dogs and joggers.

c) There are several other broad categories of bikeway users that may be less common than those described above. These include:

   i) people with disabilities – pedestrians with walking aids, wheelchair or electric gopher users;

   ii) small-wheeled vehicles – children’s pedal/motorised/electric cars, in-line skaters, skate boarders, roller skaters, and foot scooters; and

   iii) maintenance vehicles – ranging from light mowing equipment to heavy trucks associated with maintenance of public utilities and associated infrastructure, or the emergency services (police, ambulance, fire etc.).

d) Bikeways are often located within linear reserves and service easements, or along coastlines and watercourses. Their placement in these areas can be associated with adverse conditions, including weak subgrades and the potential for periods of inundation by floodwater.

Figure 1-1 Share Use Path

1.2.2 Bikeway widths

Bikeway widths vary between 2.5 m and 4.0 m according to the type and nature of the bikeway as detailed in Austroads Guide to Road Design Part 6A.

1.3 Bikeway surfaces

1.3.1 Function of bikeway surfaces

a) The wearing surface is the uppermost layer of a pavement structure over which the users of a bikeway are required to travel. Its overall function is to provide a safe, economical, and all-weather surfacing that is:

i) smooth;

ii) skid resistant;

iii) dust-free;

iv) waterproof;

v) durable; and

vi) protective of the underlying pavement structure.

b) In addition, bikeway surfacing are often required to perform aesthetic or social functions that include:

i) visually enhance the bikeway environment for users and adjacent residents; and

ii) to assist in separating user groups.

1.3.2 Types of surfacing

The general types of surfacing typically used for new bikeway pavements (and as resurfacing treatments) are briefly described as follows:

a) Unsealed surfaces which consists of granular materials of up to about 20 mm in stone size are typically used as the principal load bearing layer and can also provide the riding surface. The mechanical interlock developed between the larger stones provides the shear strength while the plastic fines in the material bind the surface of the layer;

b) Sprayed seal treatment which consists of a layer (or multiple layers) of stone chips spread and rolled onto a thin film of sprayed bitumen to form a water-resistant surfacing over granular layer(s) as shown in Figure 1-2;

Figure 1-2 Sprayed seal bikeway

c) Bituminous slurry and micro-surfacings which is a slurry mixture of sand, crushed rock, filler, cement and bituminous emulsion applied to form a thin surfacing layer. Slurry surfacings tend to be very thin (<12 mm), have a fine surface texture, and are relatively brittle when compared to asphalt. They can also be used to correct minor surface irregularities. Micro-surfacings are a form of slurry surfacing in which the conventional bituminous emulsion is replaced by a polymer-modified emulsion to provide faster setting times and improved flexibility;

d) Asphalt, or hot mix, surfaces which consists of a mixture of well-graded, clean, non-plastic granular material and 4.5% to 7% bitumen by mass, which is produced in a purpose-built mixing plant. When compacted and cooled it forms a smooth, stable, and durable riding surface;

e) Concrete surfacing is the finished top of the structural base layer rather than a separately placed surfacing treatment; and

f) Concrete block pavers which are about the same size as clay house bricks are placed over a thin sand bedding layer and granular material.

1.3.3 Performance characteristics

a) Monitoring of the performance of a bikeway surfacing requires the assessment of relevant parameters in two principal categories:

   i) functional - surface shape and appearance, ageing effects, concrete slab faulting (stepping), roughness, skid resistance and surface texture; and

   ii) structural - cracking, deformation, potholes, and pavement strength deterioration.

b) In practice, many of these factors are inter-related. Increasing roughness may be an indication of deteriorating structural strength. Loss of texture due to bleeding or stripping of a sprayed seal will lead to non-uniform skid resistance.

c) Ageing of surfaces may lead to brittleness, cracking or increased permeability, thereby allowing moisture to enter and weaken the underlying pavement structure. Ageing may also lead to ravelling and the initiation of potholing. The potential for skidding may be influenced by poor drainage, bikeway geometry, surface roughness, as well as surface cleanliness.

1.3.4 Investigation levels

a) The levels at which investigation should take place are referred to as indicative investigation levels (IILs). Investigation levels and intervention treatments based on broad experience are provided for general guidance in section 5 and Appendix 1: Proposed intervention treatments. However, there are likely to be circumstances in which these are inappropriate for local operating environments, or for technical or economic reasons.

b) The investigation levels typically utilised with pavements are:

   i) surface shape;

   ii) roughness;

   iii) skid resistance; and

   iv) cracking.

1.4 Economic considerations

a) Cost effective designs for bikeway pavements should take into consideration not only the initial construction costs, but also those associated with the maintenance and rehabilitation of the pavement structures.

b) These costs are directly or indirectly related to the following:

   i) pavement loads;

   ii) environmental factors;

   iii) material properties;

   iv) construction practices;

   v) pavement performance; and

   vi) maintenance treatments.

c) The cost of bikeway pavements can vary significantly depending upon a number of parameters, particularly the surfacing and base type. If sufficient capital funds are provided for a well designed and constructed facility, this will usually minimise on-going long-term maintenance costs.

d) It is usual to adopt a Design Life of 20 to 40 years unless the bikeway is to be developed in stages as outlined in section 2.2.1. Unsealed, sprayed seal, and asphalt surfaced pavements would normally require resurfacing at intervals of less than 20 years. Typical life expectancies of the main surfacing types are indicated in Table 1-1.

e) Most bikeway designs prepared in this Guide are based on a Design Life of 20 years, but concrete pavements have been designed for 40 years.

Table 1-1 Typical surfacing life expectancies

Surfacing type	Expected service life of surfacing (years)
Sprayed seal, 5mm / 7mm	5 to 10
Double application seals	8 to 15
Dense graded asphalt	10 to 20
Fine gap graded asphalt	15 to 20
Slurry & Micro-surfacing	8 to 15
Concrete	40 (may require retexturing in this period)
Concrete Block pavers	15 to 25

f) In addition to periodic resurfacing, other maintenance activities are often required to ensure that the pavement remains effectively waterproofed throughout its service life.

g) As with road pavements, the costs for various types of bikeway pavement construction, the performance during the design life, and the on-going maintenance costs vary considerably. To compare projects on an equitable basis, whole-of-life costing can be undertaken in the same way as for road pavements.

h) Methods of economic comparison include the Net Present Value (NPV) (Austroads Guide to Pavement Technology Part 2) and Equivalent Annual Cost (EAC) (Bennett and Moffatt 1995).

i) Australian Road Research Board (ARRB) (2005a) provides information about the economic analysis of bikeways and is available onlineAssociated with that work, ARRB also developed an Excel worksheet analysis tool and user directions (ARRB 2005b).

2 Pavement selection

2.1 Pavement type

a) Bikeway pavement types fall into two broad categories, flexible and rigid.

b) Flexible pavements, as the name implies generally have a structure that deflects or flexes under load. They include sprayed sealed pavements, asphalt pavements, and unsealed pavements. Concrete block pavers and pavements incorporating cement stabilised materials are also classified as flexible and use a similar design methodology.

c) Rigid pavements have a rigidity associated with their slab action and comprise cement bound concrete pavements. The structural design procedure differs fundamentally from that used for flexible pavements.

d) Given the large range of pavement types from which to select, it is important to adequately consider the advantages and disadvantages of each.

2.2 Selection of pavement type

2.2.1 General

a) The performance of a bikeway pavement is strongly influenced by the pavement materials, quality control during construction, and the amount and timeliness of maintenance. Generally, the higher capital cost bikeways with concrete or asphalt surfaces have lower ongoing maintenance requirements and provide better cycling conditions.

b) Some authorities may have preferences for particular pavement types using local materials and based on knowledge of regional soil conditions. Where possible, maximum use should be made of local materials to gain experience in their performance, to minimise costs and to better blend with the environment.

2.2.2 Unsurfaced granular pavement

a) An unsealed granular or gravel bikeway may be considered as the first stage of the development of a route, especially where:

  i) the volume of cyclists initially expected to use the bikeway is low;

  ii) gradients are relatively flat (i.e. <3%);

  iii) the environmental amenity of the area may be reduced by a surfaced bikeway; and

  iv) construction costs need to be minimised.

b) An asphalt, slurry, sprayed seal or concrete surfacing may then be provided at a later stage.

c) Gravel paths can vary significantly in terms of design and construction details, materials, and hence performance and costs. Generally, they have higher rolling resistance and are not as easy or as safe for cyclists to traverse as asphalt or concrete paths, particularly in wet periods. While construction costs are lower, weed control and regular surface grading and replenishment with additional material would generally result in higher maintenance costs. High velocity or high volume drainage flows that intersect an unsealed bikeway may result in significant scour and erosion.

d) Materials such as crushed limestone and granitic sand that have significant cohesion and texture have been found to provide good service. Stabilisation with a cementitious binder may also be appropriate in some situations.

e) Gravel is not a suitable surface for small-wheeled devices such as in-line skates, skateboards, wheelchairs, or those with high tyre pressures and is more appropriate for recreational routes or where bicycles with wider tyres are predominant.

2.2.3 Granular pavement with sprayed treatment

a) One or more granular layers are placed and compacted prior to the application of a sprayed seal surfacing including:

  i) sprayed seal (prime and sprayed seal) - a prime (refer section 2.2.3b)i)) followed by a thin layer of sprayed hot cutback or emulsion bituminous binder onto which a single size aggregate is spread and rolled. Coarsely textured surfaces such as the single application of a large size aggregate should be avoided because of the high rolling resistance, and greater risk of rider injury and bicycle damage from a fall. Multiple application seals utilising a smaller aggregate size in the top layer, are desirable to improve surface texture.

  ii) primerseal - an application of a primer-binder applied to a prepared granular base to provide penetration of the surface, but with sufficient retained on the surface to hold a subsequent layer of small size aggregate. A primerseal also provides an adequate surfacing for cyclists as long as a small size aggregate is used. The primerseal is sprayed on a crushed rock or gravel base similar to that thickness used for asphalt paths. For road pavements a primerseal is regarded as a short-term surfacing option (up to 12 months) but under bikeway traffic up to 5 years may be achievable subject to anticipated traffic loadings.

iii) multiple application seal - a seal using multiple applications of binder and different size aggregate, e.g. first coat 7 mm or 10 mm aggregate, second coat a 5 mm aggregate. A 10/5 seal is usually the better option.

b) The following are treatments used in conjunction with sprayed surfaces:

i) prime - an application of a primer to a prepared base, without a subsequent aggregate cover, to provide penetration of the surface for waterproofing purposes and to obtain a bond between the pavement and the subsequent sprayed seal or asphalt wearing course.

ii) surface enrichment treatment - a light application of bituminous binder, without aggregate, to increase the binder content and extend the life of an existing sprayed seal surfacing.

c) Sprayed seal surfacings may not be suitable for small wheeled devices such as in-line skates, skateboards etc. Whilst considered to be a practical surfacing for cyclists, sprayed seals are less preferred than either concrete or asphalt surfacing due to their inherent coarser or more variable surface texture.

2.2.4 Granular pavement with bituminous slurry surfacing

a) One or more granular layers are placed and compacted prior to priming and surfacing with a slurry or micro-surfacing including:

i) a basic slurry surfacing comprises materials from sand to 5 mm aggregate, with filler, cement, and bitumen emulsion. Slurry seals tend to be <12 mm thickness.

ii) micro-surfacing is similar to a slurry seal but includes a polymer modified bitumen emulsion to provide faster setting for earlier trafficking, greater durability and improved flexibility. The nominal size of micro-surfacing is usually in the range 4 mm to 10 mm, placed in layers of up to 3 times the nominal size.

b) Slurry and micro-surfacings are susceptible to surface cracking and loss of surface shape, which can be initiated by soil movements or thermal and age effects.

c) Granular pavements with bituminous slurry surfacing have good rideability and serviceability for all wheeled and pedestrian traffic.

2.2.5 Granular pavement with asphalt surfacing

a) One or more granular layers are placed and compacted prior to priming and surfacing with hot mix asphalt layers including:

i) dense graded asphalt, or asphaltic concrete (AC) - a dense, durable, continuously graded mixture of coarse and fine graded aggregates, mineral filler and bituminous binder which is produced, placed and compacted whilst hot.

ii) fine gap graded asphalt (FGGA) - a dense, durable mixture containing some coarse aggregates in a mastic of fine aggregate, filler, and binder, for use in lightly trafficked applications.

iii) light duty asphalt (L) - typically another term for FGGA with additional binder that reduces the initial air voids of the mix.

b) Asphalt paths are also subject to deterioration by surface cracking and loss of surface shape resulting from soil movements or thermal and age effects. The onset of cracking due to age effects, which is a common distress mode in lightly trafficked asphalt pavements, can be deferred by constructing a surfacing with low in-situ air voids (≤ 4%). The pavement strength and load capacity are improved by providing additional asphalt layer(s) below the wearing course. The characteristics of asphalt bikeways are summarised in Table 2-1.

c) Granular pavements with asphalt surfacing have good rideability and serviceability for all wheeled and pedestrian traffic.

2.2.6 Concrete

a) Concrete pavements normally consist of a low strength granular subbase layer supporting a high strength cement bound base layer with textured surface created by either:

   i) hessian dragged - a medium surface texture for main roads and residential streets; or

   ii) transversely broomed - a fine texture for low-speed applications such as bikeways.

b) Several types of concrete road pavements are constructed in Australia with the most common being a jointed unreinforced (plain) concrete pavement (PCP). For bikeways, a variant of this with continuous mesh reinforcement within the concrete base slab is common within the eastern States. They are usually expected to provide better long-term performance where the alignment is constructed on reactive soils and non-uniform support or is located near trees that can cause root damage.

c) The contrast between the colour of line marking and concrete surfaces may be poor in some situations, but the reflectivity of concrete tends to assist path definition in low light. The characteristics of concrete bikeways are summarised in Table 2-1.

d) Good rideability and serviceability for all wheeled and pedestrian traffic.

Table 2-1 Summary of asphalt and concrete pavement bikeway characteristics (based on Bikewest 1988)

Criteria	Asphalt	Concrete
Surface	Flexible, smooth witih no construction or expansion joints. Allows a smoother surface where adjacent tree roots cause deformations in the pavement. Suitable in areas susceptible to ground movement but may still result in cracking and deformation.	General surface is smooth, but construction and expansion joints can introduce rider discomfort. Tree roots can cause faulting or stepping.
Construction	Construction difficulty is low where equipment has the room to manoeuvre. Detail work, e.g. ramps at kerb lines, may require a mixture of concrete and asphalt work. Asphalt must be hand-laid in confined areas. Edge restraint preferred, especially in developed areas. Full depth asphalt recommended around service and inspection pits to prevent subsidence and uneven surface. Trench and other reinstatements become patchwork, affecting surface uniformity and aesthetics. Less costly to reinstate than concrete because repairs are restricted to the disturbed area.	Less and smaller equipment required to construct. Single material, one-step construction process, including details such as ramps and kerbs. No edge restraint required. Concrete surface more easily matched to be flush with service holes and pits with little likelihood of subsidence. Reinstatements can be made flush with adjacent paving with less likelihood of subsequent subsidence. However, reinstatement can still be patchwork in appearance unless complete slabs are reconstructed. More costly to reinstate whole slabs in cases of minor disturbance.
Construction detail requirements	Suitable edge restraint flush with surface is preferable for asphalt surfaced bikeways. Backfilling to the edge restraint should be finished to the level of the path surface. Flush shoulders required if no other permanent edge restraint is provided.	No edge restraint required. Contraction joints should be sawn rather than formed. Provides a non-slip surface, usually a broom finish
Maintenance	Bitumen acts as a nutrient for grasses such as couch and tends to attract and promote such growth. Maintenance spraying to control weed ingress is essential.	Expansion jointing material should be kept marginally below the finished surface. Construction and expansion joints require regular weed control.

2.2.7 Concrete block pavers (CBPs)

a) Interlocking concrete block pavers of various types are used for a range of road and path pavements. They are often selected for their aesthetic appeal and placed in local recreational areas with substantial foot traffic.

b) Pavers are normally placed over one or more granular layers and about 25 mm of bedding material. Jointing sand is required to assist the mechanics of interlock.

c) CBPs with chamfered edges are generally unsuitable for small wheeled devices such as in-line skates, skateboards etc.

Figure 2-1 Concrete block paver shared bikeway

2.2.8 Coloured pavements

a) Concrete pavements

i) the colouring of concrete pavements can be achieved through the use of oxides and pigments added to the topping mix, for a limited range of colours. Information about the performance of these products should be sought from the supplier. Concrete block pavers come in a range of colours.

b) Asphalt and slurry pavements

i) Mixes

A. Coloured asphalt became available in South Australia during the late 1980s using two methods. In the first, clear synthetic binder and oxide colourings are added to the mix through the batch plant, requiring thorough cleaning and preparation of the equipment. High production costs result in unit rates about 3.5 to 4 times that of conventional asphalt.

B. Alternatively, standard black bitumen binder is coloured with heavy dosages of oxide to produce a limited range of colours. This process is also expensive compared to the cost of normal asphalt, and the large amount of additive may affect the asphalt properties.

C. Both methods of preparing coloured asphalt are assisted by the use of a compatible aggregate colour.

ii) Coatings

A. The following characteristics are critical to successful long-term performance of coloured coatings for asphalt and slurry surfaced bikeways:

I. ease of maintenance;

II. high skid resistance for the life of the coating;

III. no visible wear (% area intact) after 5 years; and

IV. colourfastness for a period exceeding 5 years.

B. The application of conventional coatings to dense or open graded asphalt pavements generally results in localised reduction in skid resistance and a loss of texture depth, which will compromise the performance of the bikeway for users. Coatings must therefore incorporate particles that reinstate the micro-texture of the pavement. These characteristics are achievable with a number of commercially available coating systems, but at a relatively high cost. The cost is a function of the specialty binders and aggregates used to provide colourfastness, durability and skid resistance.

C. The application of a coating system also introduces long-term maintenance obligations if the appearance and performance of the bikeway is to be effectively maintained. For this reason, the use of coatings to provide a coloured pavement surface would not normally be regarded as a routine pavement treatment. It is more likely that coating systems would be limited to special conditions that warrant the high additional costs such as approaches to road pavements or path intersections.

iii) Spray seals

A. Where available, naturally occurring coloured aggregates can be used with conventional binders to provide a coloured surface.

B. The use of any coating system with a sprayed seal is not recommended due to limitations in the durability and the likelihood of significant maintenance costs. In addition, the coarse surface texture requires high application rates of the coating that increases the initial and subsequent treatment costs.

2.2.9 Paving fabrics

a) Geotextile reinforced seals have been used successfully with marginal pavement materials and can be applied directly to stabilised clay subgrades in low traffic situations. They are also suitable for resealing cracked pavements and in situations where cracks are large, but crack movement is relatively slow.

b) Paving fabrics used with sprayed seals or as an interlayer treatment with slurry, micro-surfacing or asphaltic wearing courses are likely to provide better resistance to reflective and environmental cracking of these surfacings. This strategy has been observed to deliver good pavement performance outcomes, with a change from large, wide (>10mm) singular cracks that are unserviceable to a spread of fine cracks that are serviceable, if still unsightly. There is still a limit to how much benefit can be derived where conditions are particularly poor though and deeper treatment to address underlying subgrade issues is needed in this situation.

2.2.10 Bikeway selection based on structural criteria

a) In selecting the pavement and surfacing type for a particular bikeway design situation, there are several parameters that require careful consideration. The common pavement and surfacing types can be designed to provide acceptable service for a wide range of environments and users. However, not all options will be the most appropriate and/or cost effective for the specific design situation.

b) Some of the key factors that require adequate consideration in the pavement and surfacing selection include:

i) presence of expansive soils (reactive clays);

ii) expected condition monitoring and future maintenance effort;

iii) drainage and moisture environment;

iv) user needs, heavy traffic requirements and traffic type;

v) community expectations;

vi) material availability, preferences, costs;

vii) available construction expertise, equipment, access, supervision, timing;

viii) level of performance and Design Life required; and

ix) initial and ongoing funding.

c) Most of these issues are related to the structural performance of the bikeway pavement and their relevance or importance to a particular project can usually be evaluated against objective criteria. The design should then be completed within the appropriate design assumptions and project constraints to ensure satisfactory performance.

2.2.11 Bikeway selection based on functional criteria

a) The functional requirements and factors affecting the selection of the bikeway type are likely to be difficult to categorise. The assessment tends to be more subjective, and the importance assigned to the functional requirements and factors is likely to vary significantly between different sites, users, and owners. Hence it is not practicable to 'flowchart' this selection process.

b) However, while not necessarily a complete list, the following items may assist the consideration of other functional factors affecting the selection of the bikeway pavement type:

i) delineation:

A. surface type (and hence colour) to define a shared-use path or define the bikeway crossing another paved area;

B. high use at night; thus a surfacing of a lighter colour;

ii) aesthetics:

A. visual impact on adjoining residences/businesses;

B. compatibility with natural surroundings;

C. heritage issues for surface type;

D. landscape design determining pavement and / or surface type;

E. are bikeway pavement edge restraints to be avoided;

iii) ride quality:

A. no joints at all;

B. a quiet surface required (e.g. roller-blades and skateboards);

iv) construction:

A. access for mechanical pavers or large equipment;

B. if hand-laid or small plant used, will surface finish quality be acceptable;

C. does industry have the equipment, materials, and skills available locally;

D. are there numerous vertical level constraints to be accommodated along the bikeway;

E. does the time of year (climate or industry supply) have an effect on the pavement type;

F. gradient and change of grade;

v) trees:

A. will roots grow beneath and distort the pavement;

vi) Flooding:

A. is inundation of pavement a concern. May also lead to loss of structural integrity;

vii) maintenance:

A. access for works, condition monitoring, timeliness, funding, work quality; and

viii) widening:

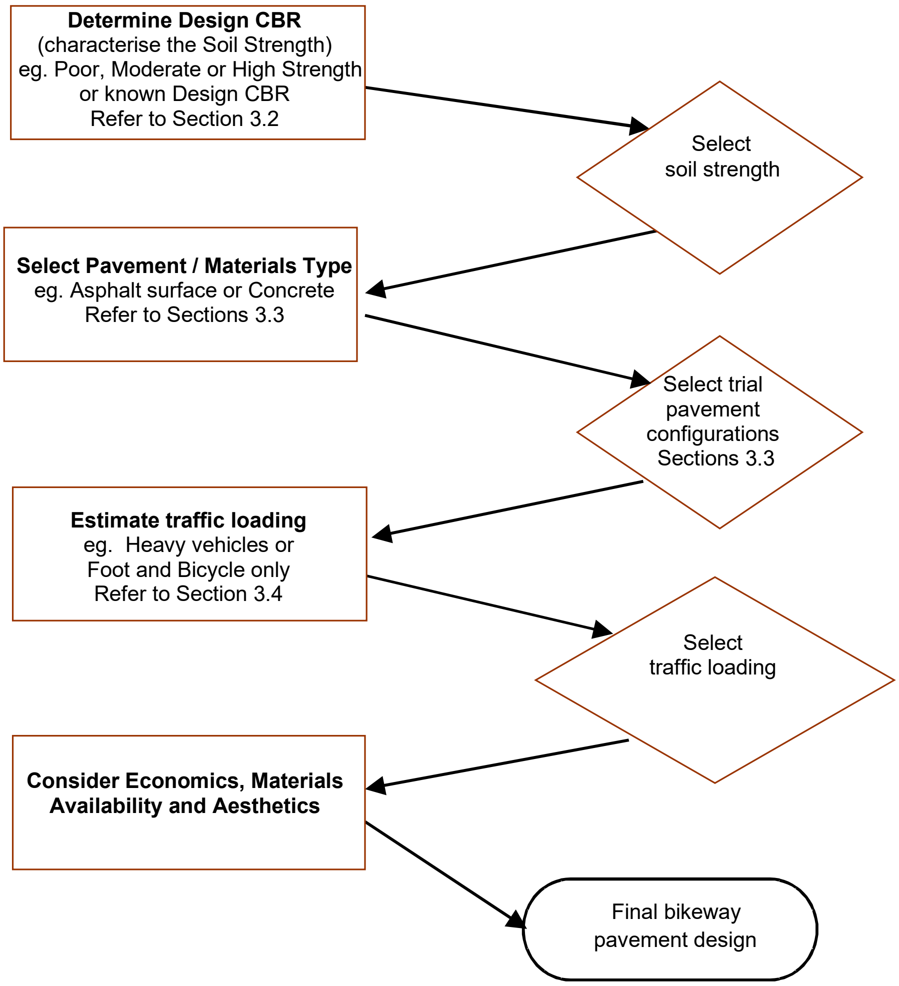
A. Possibility of future improvements.

3 Pavement design guidelines

3.1 Design process

a) The general design process for the bikeway pavement is shown diagrammatically in Figure 3-1 with the relevant section references.

Figure 3-1 Design process



b) Appendix 2: Technical basis for bikeway designs provides a brief description of the technical basis and assumptions associated with the selection of the subgrade and traffic loading design parameters used in this Guide.

3.2 Subgrade evaluation

3.2.1 General

a) The subgrade is the natural soil horizon (or rock formation) upon which the bikeway pavement is founded. It may also comprise imported materials (fill), placed many years prior to, or as part of the works associated with the bikeway.

b) The support provided by the subgrade is one of the key factors affecting the long-term performance of the bikeway. Pavement thickness requirements are highly dependent on the amount of support provided by the subgrade, particularly for bikeways subjected to heavier vehicle movements.

c) If there is uncertainty in the selection of an appropriate support value for use in structural design, then conservative values should be used, or expert advice sought from pavement engineering specialists.

3.2.2 Subgrade strength

a) General

i) subgrade strength has traditionally been defined by determining the California Bearing Ratio(CBR) and a typical range of values representing weak to very strong soils would be 2% to 15%.

ii) the subgrade strength may be generally categorised as follows:

A. Very Low Strength Subgrade – Design CBR <2%;

B. Low Strength Subgrade – Design CBR 2% to 4%;

C. Moderate Strength Subgrade – Design CBR 5% to 9%; and

D. High Strength Subgrade – Design CBR ≥10%.

iii) it is noted that computer modelling for pavement design (mechanistic analysis) requires subgrades to be characterised by an elastic or resilient modulus. Austroads has adopted a simple empirical relationship between CBR and modulus: E (MPa) = 10 x CBR.

iv) in selecting the subgrade strength category (and Design CBR value), consideration needs to be given to the weakest subgrade condition that the bikeway will endure during its Design Life. This may not be represented by the conditions occurring at the time of investigation or during construction, and therefore should generally be a conservative assessment for several reasons:

A. it is difficult to accurately predict changes in soil strength for 20 or more years into the future. The effectiveness of in-service pavement drainage and the large range of environment influences often introduce significant uncertainties.

B. the amount of laboratory and in situ test data on subgrade soil strengths for bikeway projects is likely to be limited.

C. the bikeway designer usually has little direct control of construction variables or the future maintenance efforts.

D. the additional construction costs of a robust pavement design are invariably relatively minor in comparison to the cost of the remedial works associated with deficient designs.

v) it is expected that low and moderate strength subgrade soils would be the most common subgrade strength categories used in bikeway designs.

vi) a further consideration in selecting the design subgrade strength relates to the preparation that occurs during construction.

vii) except for loose in-situ granular soils, the strength of most subgrades is likely to benefit where construction disturbance is kept to a minimum, as the undisturbed, in-situ soil structure will often have intrinsic strength that is usually worth preserving, and which can be degraded from poor construction practices. In most cases box out and proof rolling will be adequate for site preparation, provided that sufficient site supervision, controlled plant and equipment movements, moisture management and compatible pavement construction methods are adopted to minimise the potential for subgrade degradation.

viii) in addition to effects on subgrade strength, alteration of the subgrade moisture content via construction or poor site management can have other adverse effects. For example, increasing the moisture content of clay subgrades by reworking them or from exposure to wet weather, can lead to in-service pavement cracking and deformation, if the effects of vegetation, low rainfall, and/or high evaporation rates later dry back these soils. Poor moisture conditioning can also lead to construction difficulties and creation of very low and low strength subgrade conditions). Best construction practice usually aims to avoid altering the moisture conditions of clay subgrades, particularly when they are considered to be near equilibrium, with careful proof-rolling used for quality assurance of sound areas and to identify any soft spots (very low and low strength subgrades) which may require local improvement.

b) Very low and low strength subgrade

i) very low and low strength subgrades apply to design CBR selection of <2% and 2% to 4%, respectively.

ii) some situations where very low and low strength subgrade conditions may apply include:

A. along river valleys, estuaries, and flood plains where poorly drained alluvial deposits exist,

B. areas subject to poor drainage and inundation; or

C. areas with climatic conditions that maintain a moist environment.

iii) where very low and low strength subgrades are present in their weakest condition at the time of construction, they would likely require pre-treatment to enable the pavement to be constructed. This pre-treatment may comprise:

A. removal and replacement with a stronger fill material to provide a better working platform to construct from;

B. in-situ stabilisation using lime, if soil conditions are compatible;

C. use of a geosynthetic as a support and separation layer; or

D. combinations of the above treatments.

iv) of these subgrade improvement options, the use of geosynthetics is commonly adopted by the Department for subgrade support and separation and is generally an acceptable practice for treatment of low strength subgrades below bikeway pavements. Very low strength subgrades are likely to require additional, more robust pre-treatment solutions.

v) the requirement for subgrade pre-treatment may not arise if the soils are not in their weakest condition at the time of construction, such as may occur with clay subgrades during and at the end of summer. For this reason, there are often cost savings or expediencies to be gained if the construction timing is selected accordingly.

c) Moderate strength subgrade

i) a moderate strength subgrade is assigned design CBR of 5% to 9%.

ii) some situations where these moderate strength subgrade conditions exist include:

A. areas with good drainage, e.g. embankments and hill slopes;

B. climatic conditions causing perennially low soil moisture content;

C. sands and low plasticity clays not subject to saturation; or

D. controlled (engineered) fills comprising select fill materials placed to the requirements of Master Specification Parts.

iii) moderate strength subgrade conditions would generally not require pre-treatments except for removal or compaction of any loose materials prior to proof rolling and subsequent construction of the pavement.

d) High strength subgrade

i) high strength subgrades are assigned design CBR of 10% or greater, noting that the Department specifies a maximum vertical modulus of 100 MPa must apply to soil subgrades and where sound rock formations exist, a maximum value of 150 MPa is applicable (i.e., equivalent maximum design CBR values of 10% and 15%, for soil and sound rock subgrades, respectively).

ii) assignment of high strength subgrade for a bikeway project should only follow expert advice and a site inspection, and preferably be based on a detailed site investigation and laboratory testing.

iii) some situations where high strength subgrade conditions may occur include:

A. areas with weathered rock profiles;

B. stabilised soils, where the high strengths have or will be confirmed via laboratory and/or in situ testing;

C. controlled (engineered) fills comprising quarried or recycled pavement materials placed to Department specifications; or

D. semi-arid and arid and well drained environs.

iv) it is expected that high strength subgrades would occur rarely within significant lengths of a bikeway project. Some exceptions might include a sandy coastal environment or through hilly areas of rock or gravel deposits.

3.2.3 Presumptive values

AGPT Part 2 (2024) provides presumptive values of subgrade support for the common soil groups. These should only be used indicatively when no testing data is available and are summarised in Table 3-1.

Table 3-1 Austroads presumptive design CBR values

Description of Subgrade		Typical CBR Values (%)	
Material	**Unified Soil Classification Classification (USC)**	**Excellent to good drainage**	**Fair to poor drainage**
Highly Plastic Clay Silt	CH ML	5 4	2-3 2
Silty Clay Sandy Clay	CL CL	5-6	3-4
Sand	SW, SP	10-18	10-18

3.2.4 Subgrade assessment and testing

a) It is good engineering practice to test the subgrade in order to assess the bikeway founding conditions and to assist in the determination of the appropriate subgrade strength category and Design CBR value, rather than to assume site conditions and adopt presumptive Design CBR values.

b) To assist in the determination of an appropriate subgrade strength category and representative Design CBR some or all of the following steps can be undertaken. Using the data obtained from the steps below, an experienced geotechnical or pavements engineer is better informed to assign an appropriate Design CBR for the bikeway subgrade.

i) available soil strength data

A. if an adjacent road pavement has been constructed within the last decade or so, soil strength data may be available in the design investigation report for that project. This should be used with caution, as the thicker road pavement is likely to be founded at a lower depth, and the bikeway supporting soils and drainage conditions may differ.

ii) site investigation and testing including:

A. observation and assessment of site conditions, factors and influences, that could impact of subgrade strength;

B. test pits and/or boreholes (after locating and clearing of underground services) to assess the subsurface stratigraphy and moisture regime, through engineering logging, and determine and sample the predominant / critical subgrade conditions;

C. assessment of in situ soil strengths, via:

I. hand penetrometer testing of exposed or recovered cohesive soils. A rough correlation of CBR = 3 x PP (kg/cm2) has been previously used by the Department; and

II. dynamic cone penetrometer (DCP) testing adjacent to the test pit or borehole so that the soil strength and soil stratigraphy can be correlated, and in situ CBR assessed from published correlations; and

D. in situ testing during the site investigation can provide good in-situ strength information if undertaken during winter or spring. Seasonal effects usually limit the value of in-situ testing conducted in summer and autumn.

iii) laboratory testing of samples retrieved from the test pits or boreholes would normally include:

A. unsoaked and/or soaked CBR testing (particularly for larger projects);

B. laboratory classification and Estimated CBR calculation (Department test procedure, TP133), based on:

I. particle size distribution; and

II. Atterberg Limits testing, to provide the Liquid and Plastic Limits (and hence the Plasticity Index), and Linear Shrinkage of the soil;

C. field moisture content;

D. calculation of an estimated CBR value is useful for soils where ≥75% passes the 2.36mm sieve, but these values need to be used with caution and in consideration of the in-situ moisture conditions; and

E. The Department has observed the following general trends in Estimated CBR values for cohesive soils using the ratio of the Field Moisture Content to the Plastic Limit (FMC/PL):

I. if the FMC/PL ratio is < 1.0, the Estimated CBR value is usually a conservative representation of the in-situ CBR;

II. when the FMC/PL ratio is within the range 1.0 to 1.3, the Estimated CBR value is usually a reasonable representation of the in-situ CBR and is often similar to a CBR inferred from the DCP test result; and

III. for a FMC/PL ratio > 1.3, the Estimated CBR value can overestimate the in-situ CBR and should not be used in design.

3.2.5 Expansive subgrades

a) Effects and treatments

i) expansive subgrades comprise volumetrically unstable clay soils that shrink on drying and swell on wetting, and are characterised by low, moderate, high, or very high reactivity.

ii) moisture changes occurring in clay subgrades with even low to moderate reactivity can cause surface damage in light duty pavement structures such as bikeways. Severe subgrade movements often lead to the development of numerous wide surface cracks and long wavelength undulations (typically > 0.5 m to 10 m long), which may result in poor rideability for cyclists. If the pavement surfacing cracks are very wide and longitudinal or a step fault develops due to the volume change, this may also present a safety issue. Undulations can cause surface water to pond, affecting users and often resulting in further localised damage to the pavement.

iii) in general, it can be difficult to provide successful solutions for highly or extremely reactive subgrades. This particularly applies to situations where the transpiration of nearby trees and shrubs has a large influence on the moisture levels of soils underlying the bikeway. As the problems associated with expansive soils are directly related to their moisture variations, treatments that minimise the moisture changes are usually the most effective.

iv) in South Australia, where low rainfalls and high evaporation rates are common, the depth from the surface to soils that maintain a year round equilibrium moisture content is about 4m. This means that stabilisation of subgrades located within the uppermost 0.2 m to 0.4 m of the soil profile may not be an effective reactive soil treatment for deep deposits.

b) Assessment of soil reactivity

i) the presence of expansive soils can often be determined from a site inspection. Indicators of the presence of expansive soils include:

A. severe cracking of dried-out soils;

B. longitudinal and meandering cracks in existing pavements;

C. tilting signposts and other minor structures which are founded near the ground surface;

D. evidence of differential movement in nearby buildings; typically, severe cracking in masonry walls; and

E. undulating kerb and channel, often with ponding occurring in the channel.

ii) Table 3-2 provides a guide to classification of expansive soils.

Table 3-2 Guide to classification of expansive soils (Austroads 2024)

Expansive Nature	Liquid Limit (%)	Plasticity Index	PI x %<0.425mm	Potential[1] Swell %
Very high	>70	>45	>3200	>5.0
High	>70	>45	2200-3200	2.5-5.0
Moderate	50-70	25-45	1200-2200	0.5-2.5
Low	<50	<25	<1200	<0.5

Table notes:

a) 1. Swell at OMC and 98% MDD using Standard compactive effort; 4-day soak, 4.5kg surcharge

3.3 Pavement material

3.3.1 Granular material

a) General

i) some granular materials can provide an adequate riding surface for bikeway pavements but more commonly they are used to construct the base and subbase layers.

ii) granular material comprises a range of stone particle sizes compacted to a dense matrix to spread traffic loads to the underlying weaker materials. The component particles range from clay size (< 2 μm) to silt and sand, to aggregate size. The diameter of the largest size aggregate (in mm) is typically used to name the granular material (e.g. a nominal 20 mm material may be called a fine crushed or a 20 mm dense-graded aggregate). The Department uses the terminology of PM2/20 to denote a 20 mm Class 2 material.

iii) granular material may comprise either naturally occurring soils such as gravel and coarse sands or be processed by crushing and screening a larger size source rock or recyclable material such as waste concrete.

b) Base and subbase granular material

i) base and subbase material quality is defined by several engineering properties, such as-

A. a particle size distribution (grading), to produce mechanical strength;

B. a limited range of plasticity, so when moist it retains good strength; and

C. values of hardness or durability that resist long term deterioration within the pavement.

ii) to achieve the above properties, bikeway designs typically use Class 2 and Class 3, 20mm nominal maximum particle size, quarried or recycled granular materials from Master Specification Part RD-PV-S1 "Supply of Pavement Materials".

c) Bedding sand

i) a well-graded coarse sand/fine gravel material of low to nil plasticity is recommended to bed Concrete Block Pavers. Washed sand is often selected so that plastic fines and any salts that may cause efflorescence are removed. Similarly, jointing sand is required between blocks to ensure that the pavers lock-up and spread the heavier loads. Typical bedding and jointing sand specifications are provided by CMAA PA02 (2022).

d) Select fill

i) select fill serves as a capping layer over weak subgrades to provide an immediate and long-term increase in bearing capacity, which facilitates placement and compaction of the pavement layers.

ii) two other properties required for select fill comprise:

A. a weighted PI (% passing the 0.425 sieve x the PI) of less than 1000, to eliminate expansive material; and

B. a maximum particle size of less than 40% of the constructed layer thickness, to provide some mechanical interlock, minimise segregation, and reduce permeability.

iii) Type A fill material (Master Specification Part RD-EW-C1 "Earthworks") generally achieves the above properties and when suitably engineered provides good shear strength and workability due to its granular nature and controlled plasticity.

iv) Type A fill material may typically comprise sand, sandy clay, natural rubble, quarry or pit overburden or by-product. Materials such as mica, shale and similar laminated materials, adherent coatings or other foreign material must not be present in form or sufficient quantity to produce adverse effect upon the usage and performance of the material.

3.3.2 Asphalt

a) General

i) asphalt or asphaltic concrete is used primarily as a surfacing material for bikeways and to a lesser extent as both surfacing and base layers if constructed as a thick asphalt pavement.

ii) asphalt comprises a range of sizes of mineral aggregates, bitumen binder and air, that is mixed, placed, and compacted whilst hot. As with granular material, the largest size aggregate in millimetre diameter is used to define the particular mix. Department asphalt mix designations are based on ensuring there is a minimum of 10% of the nominal size material within the mix. Asphalt containing a mixture of aggregate of maximum 7 mm size produces size 7 asphalt, e.g. FineAC7L as per Master Specification Part RD-BP-S2 “Supply of Asphalt”.

iii) typical sizes of asphalt used for bikeways include 5 mm, 7 mm, 10 mm and 14 mm. The finer the size the more closed the asphalt surface is in terms of texture. Smaller size mixes are used for surfacing layers, as these may be laid thinner than larger size mixes and are generally easier to hand-place to obtain a good finish. However, the smaller mixes have lower stability and shear strength than larger mixes. If very heavy axle loadings are expected, or the surfacing/base layer is reasonably thick, a larger size mix may be more appropriate.

b) Asphalt for thin surfacing

i) asphalt placed in thin surfacing layers can be relatively porous compared to a sprayed seal, and the underlying granular base needs to be treated using a prime or primerseal (refer to Section 6.3).

ii) the prime comprises bitumen either dissolved in kerosene (hot cutback) or emulsified in water (emulsion) such that when applied it is able to penetrate the top few millimetres of the granular material. This deposits a dispersed matrix of bitumen particles within the surface of the granular material and thereby assists in moisture proofing and bonding to overlaid bituminous surfacings. If the underlying pavement material or subgrade is particularly sensitive to moisture ingress (expansive soils etc), a cutback or emulsion primerseal will provide a much better moisture barrier than a prime.

iii) a tack coat is placed over the primed surface just prior to placing the thin asphalt surfacing to bond the surfacing to the granular base layer. Tacking between clean fresh layers of asphalt is generally not required as the heat within the overlaying mix assists adhesion.

c) Low air voids asphalt

i) most asphalt is specified and produced for use on relatively heavily trafficked pavements where tyre pressures, axle loads, and the number of repetitions of these loads are high. The design of these asphalt mixes allows for the reduction of air voids caused by traffic during the initial few years of service.

ii) if similar asphalt is used on bikeways where it would not be sufficiently worked by traffic to reduce the air voids content, it remains susceptible to oxidisation and degradation by contaminants. This may result in the asphalt surfacing becoming prematurely brittle and more susceptible to ravelling, cracking and fretting.

iii) special asphalt mixes have been designed for light traffic applications. To reduce the initial air void content, the mix may be gap-graded and/or more bitumen binder added. Table 3-3 shows some of the available mixes used for light traffic.

Table 3-3 Asphalt types for light traffic

Source	Name	Properties	Reference
Department	FineAC7L, FineAC10L (7mm and 10mm)	Dense graded mix with additional 0.5% binder	Department Master Specification – RD-BP-S2 “Supply of Asphalt”
Austroads	Dense and Fine Gap Graded and Stone Mastic Asphalt	Sizes 7 mm and 10 mm; (Part 4B)	Austroads (2014b) Guide to Pavement Technology Part 4B Asphalt
Australian Standard	Dense and Fine Gap Graded and Stone Mastic Asphalt	Sizes 7 mm and 10 mm; 5% to 7% bitumen by mass	AS 2150 Asphalt – A guide to good practice

d) Bitumen binder

i) bitumen binder should preferably comprise Class 170 complying with AS 2008 Bitumen for pavements. However local climatic conditions in conjunction with very light or significantly heavier loadings may warrant the use of either Class 50 or Class 320 bitumen respectively.

ii) for example, a bikeway in a very cold climate region may utilise the lower (viscosity) grade bitumen, whereas a bikeway likely to sustain heavy axle loads in a very hot areas should utilise a stiffer (more viscous) binder such as the Class 320.

iii) the use of the softer Class 50 binder may also have some advantages in resisting environmental cracking where this is likely to be more prevalent. However, in South Australia there is little local experience with C50 binder and the supply of small amounts for bikeway projects is unlikely to be practical or economically viable.

e) Modified binders

i) the bitumen binder may be modified by the addition of a range of elastomeric and plastomeric polymers or crumbed scrap rubber, to enhance the asphalt mix properties for specialised applications. These include better fatigue and deformation resistance, reduced reflection cracking, and increased durability. The development of modified asphalt has mainly targeted heavily trafficked situations and it is difficult to extrapolate this performance experience to bikeway facilities.

ii) the higher costs associated with modified asphalt may be warranted if an extended service life or better resistance to environmental cracking has been observed in comparative trials or local studies of lightly trafficked pavements.

3.3.3 Concrete

a) General

i) concrete comprises a homogenous mixture of cement binder, fine and coarse aggregate, sand, and water. Chemical admixtures can be included to retard set, reduce water, or for air entrainment. The concrete aggregate suitable for bikeways would generally be limited to a maximum size of 20 mm. Unconfined compressive strength requirements range from f'c = 25 MPa for footpath construction to 32 MPa for bikeways that are likely to have heavy vehicle loads.

ii) higher concrete strengths generally provide greater durability and better resistance to structural fatigue cracking. Thickness design for light duty pavement slabs mainly involves consideration of the magnitude and number of stress repetitions imposed by the expected loadings.

iii) durability is important for concrete pavements and is indicated by the longevity of the surface texture, and the resistance to spalling, minor edge breaks, and stepping or faulting between adjacent slabs.

3.3.4 Concrete Block Pavers (CBPs)

i) In line with section 11.5.4 of Master Specification Part RD-PV-D1 "Pavement Investigation and Design", concrete block (or segmental) pavers are individual high strength paving units of 60 mm and 80 mm standard thickness.

ii) Pavers are small in size and are not bonded to adjoining units. Hence, they also require additional sub-layers to provide adequate pavement strength over weak subgrades, typically comprising unbound or bound granular pavement materials.

iii) The Concrete Masonry Association of Australia (CMAA) provides guidance on the design and specification of concrete block pavers (CMAA 2010, 2014, 2022).

3.4 Design traffic loading

3.4.1 General

a) Two loading regimes of traffic have been adopted as follows:

i) bikeway with pedestrian and bicycle traffic only; or

ii) bikeway with maintenance vehicle loading.

b) The pavement design procedure for most situations can be completed by selecting the appropriate loading from one of these two categories. However, if better information is available for a particular bikeway project, it should be used to calculate the design traffic.

3.4.2 Design Life and units of loading

a) For flexible pavements and concrete block pavements the recommended Design Life is 20 years and the design traffic loading is expressed in terms of the cumulative number of Equivalent Standard Axles (ESA) over the 20 year design period.

b) For rigid pavements a 40 year Design Life is used. In this case the design traffic loading is expressed in terms of cumulative number of Heavy Vehicle Axle Groups (HVAG) occurring within the 40 year Design Life.

c) Table 3-5 provides design traffic loadings based on these Design Lives, but other cumulative traffic loadings could be determined for different Design Lives.

3.4.3 Pedestrian and bicycle traffic

a) The pedestrian and bicycle traffic category assumes that these and similar loadings are all that will occur on the bikeway pavement during its life. However, if the bikeway can be accessed by motor vehicles it is prudent to assume that it will be. In general, there will also be a need for access by emergency services such as police, ambulance, fire control etc, as well as for normal maintenance of the path or environs.

b) In practice, selection of this very light loading regime for design is rarely appropriate and should only be made if it is not physically possible for a heavy motor vehicle to access the bikeway. If no access is available to emergency and maintenance trucks, and very few if any 2WD vehicles will traffic the facility, then this loading category may be appropriate.

3.4.4 Heavy vehicle loading

a) In developing minimum pavement configurations in this Guide, it was assumed that all the loading is due to 2-axle rigid trucks commonly used as road maintenance vehicles.

b) These minimum designs for flexible pavements provided in RD-PV-D1 “Pavement Investigation and Design” were based on 4,000 ESA of loading. As detailed in Appendix 2: Technical basis for bikeway designs, such a loading would be caused by one pass of a 2-axle rigid truck per week over 20 years with the following axle loads:

i) 5 tonne (49.0 kN) on a single axle single tyres (SAST)

ii) 7 tonne (68.6 kN) on single axle dual tyres (SADT)

c) These loads represent a partly-laden truck with a gross mass (12 tonne) that is about 80% of the maximum prescriptive gross mass. If the bikeway is likely to sustain more frequent or heavier axle loadings, it is recommended that the design be undertaken in accordance with Austroads (2024) Austroads Guide to Pavement Technology Part 2 “Pavement Structural Design” with the design traffic loading being increased by a factor of 3 to allow for channelisation (refer Appendix 2: Technical basis for bikeway designs).

d) A design traffic loading in terms of Heavy Vehicle Axle Groups (HVAG) is required for the design of rigid pavements. The minimum designs for concrete are based on 12,000 HVAG over the 40 year Design Life, or 6000 2-axle rigid truck load repetitions of the 12t gross mass axle loadings. If the bikeway is likely to sustain more frequent or heavier axle loadings, it is recommended that the design be undertaken in accordance with Austroads (2024) Guide to Pavement Technology Pavement Structural Design and Master Specification Part RD-PV-D1 “Pavement Investigation and Design”.

3.4.5 Summary

a) Table 3-4 summarises the loading characteristics used in selection of designs in this Guide.

Table 3-4 Indicative loadings for bikeway traffic categories

Design Traffic Category	**User or Vehicle Type**					
		 motor car (2WD)	 light utility (2WD)	 Light truck <3tonne	 Trucks with gross mass less than 12 tonnes	 Trucks with gross mass greater than 12 tonnes
Foot and bicycle	✓	?	?	✗	✗	✗
Heavy vehicles	✓	✓	✓	✓	✓	✗

Note: ? indicates a few repetitions per year of this load type may be acceptable.

b) Table 3-5 provides the actual design traffic loadings used to generate the pavement designs.

Table 3-5 Recommended design traffic loadings for bikeway structural designs

Loading	**Characterised by**	**Flexible and concrete block pavements** 20 year Design Life	**Rigid pavement** 40 year Design Life
Foot and bicycle	Foot and bicycle loading only	NA	NA
Heavy vehicles	1 pass of two-axle rigid truck per week, 12t gross mass per vehicle	4,000 ESA	12,000 HVAG or 6000 truck repetitions

3.5 Flexible pavement design

3.5.1 General

a) There are five different types of flexible pavement configurations (described in section 2.2) that are considered most likely to provide the practical range of design options for South Australian bikeways:

- i) unsurfaced granular;
- ii) sprayed seal granular (with or without paving fabric);
- iii) slurry seal granular;
- iv) asphalt surfaced granular; and
- v) concrete block paver granular.

b) The structural methods used to design these flexible bikeway pavements are based on the performance of lightly trafficked road pavements. However, the performance of bikeways may differ from lightly trafficked roads due to many factors, including differences in cross-section, drainage, edge loading and maintenance.

c) The design of the above pavements must be undertaken in accordance with RD-PV-D1 "Pavement Investigation and Design". Presumptive designs indicating minimum layer and total thicknesses are tabulated for all five pavement configurations, at three subgrade strengths and two traffic loadings. However, the pedestrian/bike configurations would be unsuitable for most facilities as they are not designed to cater for maintenance vehicle loadings.

d) Alternative pavement configurations and designs can be prepared for these and other subgrade and traffic conditions by applying Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design, usually requiring some pavement design expertise.

3.5.2 Unsurfaced granular bikeways

a) Table 3-6 provides the presumptive configurations for bikeways comprising unsurfaced (or unsealed) granular material for the standard loading and soil strength categories. These pavements may not provide satisfactory performance in wet environments.

Table 3-6 Minimum designs for unsurfaced granular bikeways

Soil strength	Pedestrian & bicycle traffic only	Heavy vehicle traffic (e.g. maintenance) N_{DT} = 4000ESA
Low strength (CBR ≥ 2%)	100 mm PM3/20 or Sa-C 100 mm Type A material **200 mm total thickness**	100 mm PM3/20 130 mm PM3/20 130 mm Type A material **360 mm total thickness**
Moderate strength (CBR ≥ 5%)	100 mm PM3/20 or Sa-C **100 mm total thickness**	100 mm PM3/20 130 mm PM3/20 **230 mm total thickness**
High strength (CBR ≥ 10%)	100 mm PM3/20 or Sa-C **100 mm total thickness**	150 mm PM3/20 **150 mm total thickness**

Table notes:

a) Soaked CBR of Type A material in accordance with Master Specification Part RD-EW-C1 “Earthworks”, to exceed 15%.

b) Sa-C is crusher sand in accordance with Master Specification Part RD-PV-S1 “Supply of Pavement Materials”.

b) The designs for pedestrian and bicycle traffic only are based on engineering judgement and minimum constructable layer thicknesses. The pavement thicknesses for heavy vehicle loadings have been determined from an empirically derived relationship (Fig.12.2 Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design). This permits the designer to interpolate where the design CBR of the soil is known and differs from 2%, 5% or 10%.

3.5.3 Sprayed seal granular bikeways

a) Table 3-7 provides the recommended configurations for bikeways pavements comprising granular material surfaced with a sprayed seal, for the standard loading and soil strength categories.

Table 3-7 Minimum designs for sprayed seal granular bikeways

Soil strength	Pedestrian & bicycle traffic only	Heavy vehicle traffic (e.g. maintenance) N^{DT} = 4000ESA
Low strength (CBR ≥ 2%)	10/5 double seal 80 mm PM3/20 or Sa-C 100 mm Type A material **180mm total thickness**	10/5 double seal 100 mm PM2/20 130 mm PM2/20 or PM3/20 130 mm Type A material **360 mm total thickness**
Moderate strength (CBR ≥ 5%)	10/5 double seal 150 mm PM3/20 or Sa-C **150mm total thickness**	10/5 double seal 100 mm PM2/20 130 mm PM2/20 or PM3/20 **230 mm total thickness**
High strength (CBR ≥ 10%)	10/5 double seal 100 mm PM3/20 or Sa-C **100mm total thickness**	10/5 double seal 150 mm PM2/20 **150 mm total thickness**

Table notes:

a) Soaked CBR of Type A material to exceed 15%.

b) The designs for pedestrian and bicycle traffic only are based on engineering judgement. The pavement thicknesses for heavy vehicle loadings have been determined from empirically derived relationships (Fig. 12.2 Austroads (2024) Guide to Pavement Technology Pavement Structural Design). The design chart is reproduced in Appendix 3: Thickness design of concrete bikeways. This permits the designer to interpolate where the design CBR of the soil is known and differs from 2%, 5% or 10%.

c) Table 3-8, and Table 3-10 provide guidance for bitumen and aggregate application rates for a 10/5 double seal with and without geotextile. The geotextile option is a more robust and durable treatment usually reserved for subgrades with moderate to very high reactivity and/or facilities requiring better surfacing performance. Sprayed seals must be swept clean of loose stone chips before use by cyclists.

Table 3-8 Sprayed seal bikeways 10/5mm double seal

Treatment	Unit	Nominal application rate
Prime (AMC0)	(l/m^2)	1.0
Bottom coat C170	(l/m^2)	1.3
10 mm agg.	(m^3/m^2)	130
Top coat C170	(l/m^2)	1.0
5 mm agg.	(m^3/m^2)	250

Table 3-9 Sprayed seal bikeways with geotextile

Treatment	Units	Nominal application rate
Prime (AMC 0)	(l/m^2)	1.0
Bond coat (C170)[(a)]	(l/m^2)	0.7
Geotextile type (refer Table 11.5)		Grade 1
Bottom coat (C170)	(l/m^2)	1.2-1.4
10 mm agg.	(m^3/m^2)	130
Top coat (C170)	(l/m^2)	1.0
5 mm agg.	(m^3/m^2)	250

Table notes:

b) during hot weather a reduced bond coat application rate may be required to avoid fabric pickup.

Table 3-10 Key properties of paving geotextile

Properties	Units	Grade 1
Mass per unit area	g/m^2	>135
Wide-strip tensile strength (AS 3706.2 Geotextiles – Methods of test – Determination of tensile properties – Wide-strip method)	KN/m	>7.0
Maximum elongation range (AS 3706.2 Geotextiles – Methods of test – Determination of tensile properties – Wide-strip method)	%	40 – 60
Minimum melt temperature	^{o}C	>195

3.5.4 Slurry seal granular bikeways

a) Where a slurry surfacing is considered to be an appropriate treatment, the underlying granular pavement structure is effectively the same as for a sprayed surfacing. Table 3-11 provides the recommended configurations for bikeways constructed of granular material with slurry surfacing for the standard loading and soil strength categories.

Table 3-11 Minimum designs for slurry seal granular bikeways

Soil Strength	Pedestrian & bicycle traffic only (a)	Heavy vehicle traffic (e.g. maintenance) N^{DT} = 4000ESA (a)
Low strength (CBR ≥ 2%)	10 mm of 5mm microsurfacing 100 mm PM3/20 or Sa-C 100 mm Type A material **210mm total thickness**	10 mm of 5mm microsurfacing 100 mm PM2/20 130 mm PM2/20 or PM3/20 130 mm Type A material **370 mm total thickness**
Moderate strength (CBR ≥ 5%)	10 mm of 5mm microsurfacing 150 mm PM3/20 **160mm total thickness**	10 mm of 5mm microsurfacing 100 mm PM2/20 130 mm PM2/20 or PM3/20 **240 mm total thickness**
High strength (CBR ≥ 10%)	10 mm of 5 mm slurry 100 mm PM3/20 **110mm total thickness**	10 mm of 5mm microsurfacing 150 mm PM2/20 **160 mm total thickness**

Table notes:

a) Nominal application rate for primes – 1.0l/m^2 and tack coats – 0.3 l/m^2 (residual).

b) The designs for pedestrian/bike traffic are based on engineering judgement. The pavement thicknesses for Heavy Vehicle loadings have been determined from empirically derived relationships (Fig. 12.2 Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design). This permits the designer to interpolate where the design CBR of the soil is known and differs from 2%, 5% or 10%.

3.5.5 Asphalt surfaced granular bikeways

a) Table 3-12 provides the recommended configurations for bikeways comprising granular material with asphalt surfacing for the standard loading and soil strength categories.

Table 3-12 Minimum designs for asphalt-surfaced granular bikeway

Soil Strength	Pedestrian & bicycle traffic only (a)(b)	Heavy vehicles traffic (e.g. maintenance) N^{DT} = 4000ESA(a)(b)
Low Strength (CBR ≥ 2%)	25 mm FineAC7 C170 100 mm PM3/20 100 mm Type A material **225 mm total thickness**	35 mm FineAC10 C170 100 mm PM2/20 100 mm PM2/20 or PM3/20 125 mm Type A material **360 mm total thickness**
Moderate Strength (CBR ≥ 5%)	25 mm FineAC7 C170 125 mm PM3/20 **150 mm total thickness**	35 mm FineAC10 C170 100 mm PM2/20 100 mm PM2/20 or PM3/20 **235 mm total thickness**
High Strength (CBR ≥ 10%)	25 mm FineAC7 C170 100 mm PM3/20 **125 mm total thickness**	35 mm FineAC10L C170 115 mm PM2/20 **150 mm total thickness**

Table notes:

a) Soaked CBR of Type A material to exceed 15%.

b) Nominal application rate for primes – 1.0l/m^2 and tack coats – 0.3 l/m2 (residual).

b) If required, a geotextile interlayer could be placed prior to the asphalt wearing course on a C170 bond coat applied at 0.7l/m^2. (Some 5 mm aggregate may need to be spread in the paver wheel paths to prevent wrinkling of the geofabric during asphalt laying.)

c) The designs for pedestrian and bicycle traffic only are based on engineering judgement. The pavement thicknesses for heavy vehicle loadings have been determined from empirically derived relationships (Fig. 12.2 Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design). This permits the designer to interpolate where the design CBR of the soil is known and differs from 2%, 5% or 10%.

3.5.6 Concrete block paver bikeways

a) In line with Master Specification Part RD-PV-D1 “Pavement Investigation and Design”, Table 3-13 provides the recommended configurations for bikeways comprising concrete block pavers over granular material for the standard loading and soil strength categories.

b) The designs for pedestrian/bike traffic are based on engineering judgement. The pavement thicknesses for heavy vehicle loadings have been determined from empirically derived relationships (Fig. 12.2 Austroads (2024) Guide to Pavement Technology Pavement Structural Design). For each subgrade design CBR, the total thickness of granular material under the blocks and bedding material was determined by subtracting the total thickness of blocks and sand (105 mm) from the total granular thickness in CMAA PA02 – 2022. This permits the designer to interpolate where the design CBR of the soil is known and differs from 2%, 5% or 10%.

Table 3-13 Minium designs for concrete block paver bikeways

Soil strength	Pedestrian & bicycle traffic only [(b)]	Heavy vehicle traffic (e.g. maintenance) N_{DT} = 4000ESA[(b)]
Low strength (CBR ≥ 2%)	60 mm CBP 25 mm bedding material[(a)] 100 mm PM3/20 100 mm Type A material **285mm total thickness**	80 mm CBP 25 mm bedding material[(a)] 125 mm PM2/20 130 mm PM2/20 or PM3/20 **360 mm total thickness**
Moderate strength (CBR ≥ 5%)	60 mm CBP 25 mm bedding material[(a)] 100 mm PM3/20 **185mm Total Thickness**	80 mm CBP 25 mm bedding material[(a)] 125 mm PM2/20 **230 mm Total Thickness**
High Strength (CBR ≥ 10%)	60 mm CBP 25 mm bedding material[(a)] 100 mm PM3/20 **185mm Total Thickness**	80 mm CBP 25 mm bedding material[(a)] 100 mm PM2/20 **205 mm Total Thickness**

Table notes:

a) Refer to CMAA (2022) and CMAA (2014) for bedding and jointing sand properties.

b) Soaked CBR of Type A Material to exceed 15%.

3.6 Rigid pavement design

3.6.1 General

a) The principal types of cementitious concrete pavements for roads are (Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design):

i) jointed plain (unreinforced) concrete pavements (PCP), generally undowelled skewed joints at 4.2 m spacings;

ii) jointed reinforced concrete pavements (JRCP), typically mesh reinforced with dowelled joints (installed perpendicular to transverse joints) at spacings of 8 to 10 m; and

iii) continuously reinforced concrete pavements (CRCP), continuous steel reinforcement to induce transverse cracking at random spacings of about 0.5 to 2 m and no contraction joints are required. Transverse reinforcement is provided to support the longitudinal steel.

b) For bikeways the pavement type is CRCP, with sawn contraction joints typically installed at spacings of 1.2 (max) times the path width and expansion joints installed every 5th contraction joint. A bound subbase is not typically needed as pumping and erosion of subbase/subgrade is unlikely to occur for the expected low-speed and low repetitions of loading. However an unbound subbase is required to provide uniform support for the concrete base..

c) Alternative pavement configurations and designs can be prepared for these and other subgrade and traffic conditions by applying Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design if loading is limited to two-axle rigid trucks.

d) The structural method used to design rigid bikeway pavements is based on the performance of lightly trafficked road pavements in Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design .

3.6.2 Example minimum pavement configurations

a) Table 3-14 shows the minimum composition for bikeways comprising a continuous lapped mesh concrete base and unbound granular subbase, for the presumptive loading and a range of soil strength categories. SL62 and SL82 mesh is used for pedestrian/bike and heavy vehicle configurations respectively. The pedestrian/bike configurations would be unsuitable for most facilities as they are not designed to cater for maintenance vehicle loadings.

b) Sand must not be used as the subbase layer for concrete, as the fine particles will eventually enter the joint spaces and restrict the cyclic slab expansion/contraction cycle.

Table 3-14 Minimum designs for concrete bikeways

Soil strength	Pedestrian & bicycle traffic only (a)(b)	Heavy vehicle traffic (e.g. maintenance) N_{DT} = 6000ESA(a)(b) (two-axle truck repetition)
Low strength (CBR ≥ 2%)	100 mm concrete (25 MPa) 100 mm PM3/20 **200 mm total thickness**	185 mm concrete (32 MPa) 150 mm PM2/20 **340 mm total thickness**
Moderate strength (CBR ≥ 5%)	100 mm concrete (25 MPa) 100 mm PM3/20 **200 mm total thickness**	175 mm concrete (32 MPa) 150 mm PM2/20 **325 mm total thickness**
High strength (CBR ≥ 10%)	100 mm concrete (25 MPa) 100 mm PM3/20 **200 mm total thickness**	170 mm concrete (32 MPa) 100 mm PM2/20 **260 mm total thickness**

Table notes:

a) 10 mm construction tolerance has been added assuming pavement constructed in accordance with Master Specification for Roadworks. Additional tolerance may need to be added where other specifications apply.

b) Designs assume maximum load on the SADT drive axle is 7 tonnes. If higher loads are expected calculate required base thickness in accordance with Appendix 3: Thickness design of concrete bikeways. The concrete base thickness design must consider fatigue by all applicable design axle-groups in accordance with section 12.9 of Austroads (2024) Guide to Pavement Technology Pavement Structural Design.

c) Designs given in Table 3-14 are derived from the procedure given in Austroads (2024) Guide to Pavement Technology Pavement Structural Design). Interpolation of these designs based on different subgrade strength is not necessary due to the general insensitivity of thickness to this parameter, and assuming design for the lower CBR is adopted. Where different traffic loadings to those given in Table 3-14 are expected, it is recommended that the design procedure in Appendix 3: Thickness design of concrete bikeways be followed.

3.6.3 Detailing

Concrete pavement designs require careful detailing of all the design elements, particularly the joints (refer to Section 4.6.2), to ensure that good long-term performance is achieved. The adequacy of the detailing has often proven to be as critical as the general thickness and reinforcement design determinations.

4 Construction

a) The sound performance of the bikeway design configuration is highly dependent on the quality of the construction works and there are a range of critical details that affect the long-term serviceability.

b) Bikeway pavements are constructed using many of the practices associated with conventional road pavements. Austroads (2009e) Guide to Pavement Technology Part 8 Pavement Construction provides further information on road pavement construction which supplements the discussion of bikeway construction issues within this Guide. Austroads (2009f) Guide to Pavement Technology Part 9 Pavement Work Practices also includes links to a number technical notes, pavement work tips and other publications provided by Austroads , Austroads member organisations and industry associations.

4.2 Surface tolerance

The new surface of a bikeway pavement should be placed to match existing features such as pit covers, edgings or driveways, to within 5 mm. It is also desirable (Austroads (1999) Guide to Traffic Engineering Part 14 Bicycles 2nd Edition) that the finished surface of a new bicycle lane or path complies with the following

does not deviate from a 3 m straight edge by more than 5 mm at any point.

4.3 Edge restraint and separation

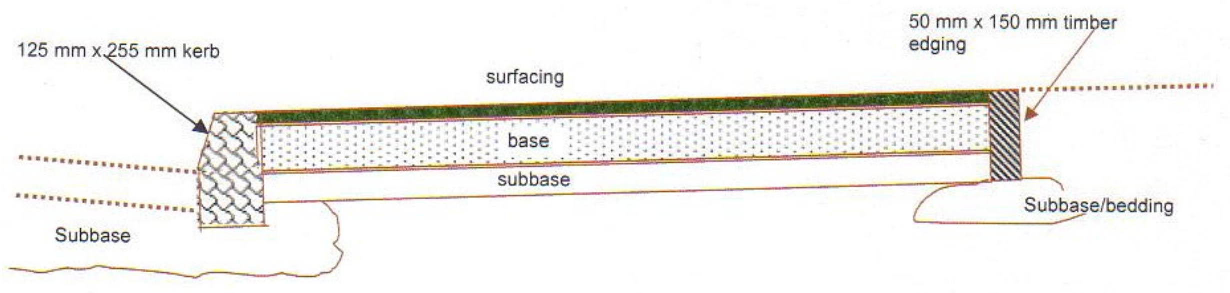
4.3.1 Restraint

a) Materials such as gravel and concrete block pavers require lateral restraint at the pavement edges to preserve their structural integrity. Thin asphalt surfacing also often requires edge restraint to ensure proper compaction and poured concrete base similarly utilises a formwork system.

b) Construction against a kerb section, wall, or concrete path provides good lateral support. Trafficking of the full width of the bikeway can then occur without a tendency to develop edge cracking and breakages.

c) Figure 4-1 shows the cross-section of typically used edge restraint systems.

Figure 4-1 Bikeway edge restraint



4.3.2 Separation

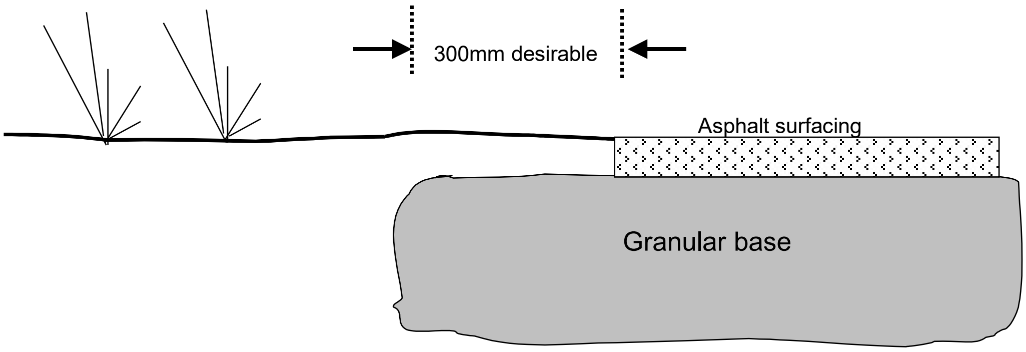
Installation of an edging system also separates the bikeway materials from the adjacent vegetation, and may reduce moisture ingress from the adjacent soil to the pavement structure. Edge treatments comprising unbound granular materials or concrete block pavers will often eventually become contaminated with topsoil or vegetation, leading to spreading and deterioration at these locations.

4.3.3 Edge restraint systems

The location and type of edge restraint may have implications for the maintenance and aesthetics of the bikeway. An exposed concrete edge of 100 to 150 mm width may assist the definition of the bikeway path (which may be important at night), and provide an edge that is more easily maintained.

The additional support provided by a wider granular base allows better edge compaction of the asphalt surfacing.

Figure 4-2 Restraint by additional width of granular base material



4.4 Granular material construction

a) For unsurfaced bikeways, aggregate sizes of 20 mm or less are preferred to ensure a satisfactory ride. With a 20 mm product, the material needs to have sufficient fine fraction and not be too hard.

b) The surface should be tightly bound and loose material should not be allowed to accumulate on the surface. Granular layers need to be adequately compacted through the full pavement depth to ensure good strength and stability. Minimum compaction requirements are indicated in Table 4-1.

Table 4-1 Recommended modified compaction levels for granular layers

Layer	Materials	Pedestrian & bicycle traffic only	Heavy vehicle traffic N_{DT} = 4000ESA
Base	PM2/20	Not applicable	96%
	PM3/20	95%	96%
	Sa-C	95%	Not applicable
Subbase	PM2/20	Not applicable	95%
	PM3/20	Not applicable	95%
	Type A	95%	Not applicable

c) Where granular pavements are to be surfaced, it is desirable to dry the compacted materials back to below the optimum moisture content before priming or sealing. This improves the stiffness of the unbound granular materials significantly to maximise the load spreading properties and provide the hard surface required prior to spraying. Sprayed seals must be swept clean of loose stone chips before use by cyclists and other wheeled transport.

4.5 Asphalt bikeway construction

4.5.1 Pre-treatment

As indicated in section 2.2.3 a prime and sprayed seal or primerseal is essential to aid adhesion both within the surface structure of the granular base, and between the granular base and a thin asphalt surface. The prime or primerseal also improves waterproofing.

4.5.2 Spreading and compaction

a) The thin layers used on bikeway pavements cool more quickly than the thicker layers typical of those used on heavily trafficked roads. Hence to achieve adequate compaction while the mix remains hot, placement should not be undertaken in cold or wet weather. Typical rates of cooling are indicated in Austroads (2014) Guide to Pavement Technology Part 4B Asphalt/Austroads/AfPA (2006) Asphalt Cooling Rates pavement work tips No. 46).

b) The performance of the asphalt is highly dependent upon achieving good compaction to reduce permeability and improve the resistance to both load induced and environmental cracking.

4.6 Concrete bikeway construction

4.6.1 General

a) The construction of concrete bikeway pavements requires good placement practices and design detailing. In addition to this Guide, further information is provided in C&CAA (2004, 1999) and RTA (2009).

b) Either double-beam vibrating screeds or slip-form pavers should be used to compact the concrete.

c) A high standard surface finish can be achieved by:

   i) The use of extended bullfloats (up to 4 m wide) to reduce the frequency and height of transverse corrugations that are undesirable on bikeways where cyclists travel at high speed.

   ii) Saw-cut contraction joints completed after bullfloating; trowelling and broom finishing, but minimising surface discontinuities and hence roughness. Wet-formed contraction joints made using a grooving tool should be avoided as discussed in Section 4.6.2a)iv).

Note: The bullfloat is a large float on a long handle, which is worked back and forth on the concrete in a direction parallel to the ridges formed by screeding. Bullfloating is useful as an initial floating operation to smooth the concrete surface immediately after screeding, and should be completed before bleed water appears on the surface. A second use of the bullfloat may be required but care must be taken not to overwork the surface.

4.6.2 Joints

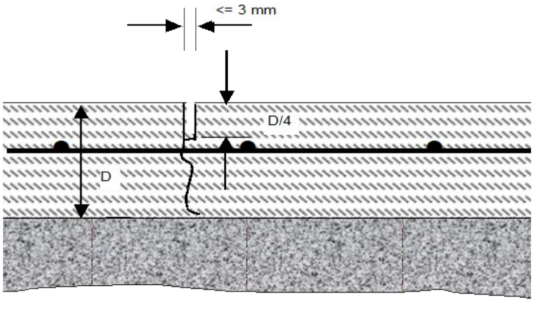
Joints in bikeway concrete pavements mainly include contraction joints, expansion and isolation joints.

a) Contraction joints

   i) contraction joints are required in the concrete base to control the location of cracks resulting from the shrinkage that occurs as concrete sets. These joints are sawn within 24 hours of casting as soon as the surface is capable of accepting the operation without damage to the base surface (refer section 4.6.2a)iii)).

   ii) contraction joints should be no more than 3 mm wide and extend into the slab by about a quarter to a third of the slab thickness (refer to Figure 4-3) but not to the depth of reinforcing mesh. These transverse saw cuts are usually required at 3.5 to 4 m spacing (but < 1.2 x path width) and should be sealed with silicone to about 10mm depth over a suitable backer rod.

Figure 4-3 Contraction joint detail



   iii) Saw cutting

      A. The purpose of shallow saw cutting is to induce shrinkage cracking only below the sawn joints where the pavement thickness (and hence strength) has been reduced. Determining the timing of the saw-cutting operation is critical, as sawing too early causes tearing or ravelling and too late results in unplanned cracking away from these joint locations.

B. Prior to commencement of a concrete bikeway project, an offsite trial section of about 12 - 20 m length should be constructed to establish and refine the proposed construction methodology. The time period between concrete placement and optimum sawing is dependent on the type and slump of the concrete and the prevailing weather conditions. Adequate sawing equipment (including spare plant) and skilled operators are required onsite during the limited time available for this critical work component.

iv) Hand-formed transverse contraction joints

A. The traditional grooving tool should be avoided as it usually forms a very wide joint at the surface (greater than 3mm) and the flat pan edges of this tool tend to create an additional surface discontinuity.

B. Any wet-formed joints must be made without disturbing the concrete within 50mm of the joint to avoid unnecessary constructed roughness.

C. Transverse brooming up to the joint opening to provide fine surface texture may reduce the magnitude of very small surface irregularities.

v) Areas comprising odd shaped or re-entrant slabs

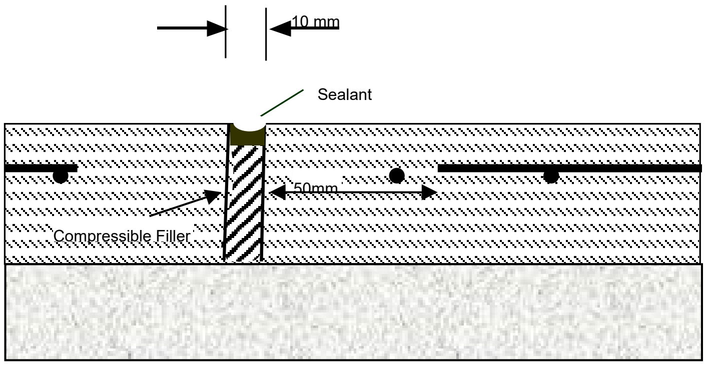
A. Odd shaped slabs or slabs containing re-entrant corners require very careful attention to joint design and location.

vi) Expansion joints

A. Expansion joints accommodate thermally induced extensions of the concrete during hot weather. These joints are often omitted on concrete roads but Austroads (2012) current best practice favours their inclusion for bikeways to ensure good long term performance. Expansion joints are generally placed at every 5th transverse joint location (e.g. 17.5m spacing when contraction joints are sawn at 3.5m intervals), but are also used at the 2nd joint away from junctions with existing flexible pavements or other structures. The reinforcing mesh is terminated 50 mm either side of the joint.

B. Expansion joints (refer Figure 4-4) must be 10-15 mm wide, sawn or formed to extend the full depth of the slab, filled with compressible filler, and provided at a minimum of 12 m to 40 m intervals (Aguero 1996).

Figure 4-4 Restraint by additional width of granular base material



vii) Isolation joints

A. An isolation joint is an expansion joint abutting a non-moveable object placed transverse to the direction of the bikeway. For example, an isolation joint would be placed at a bridge abutment or driveway crossover. These joints may also be required parallel to the bikeway direction where there are lateral restraints such as kerb and channel.

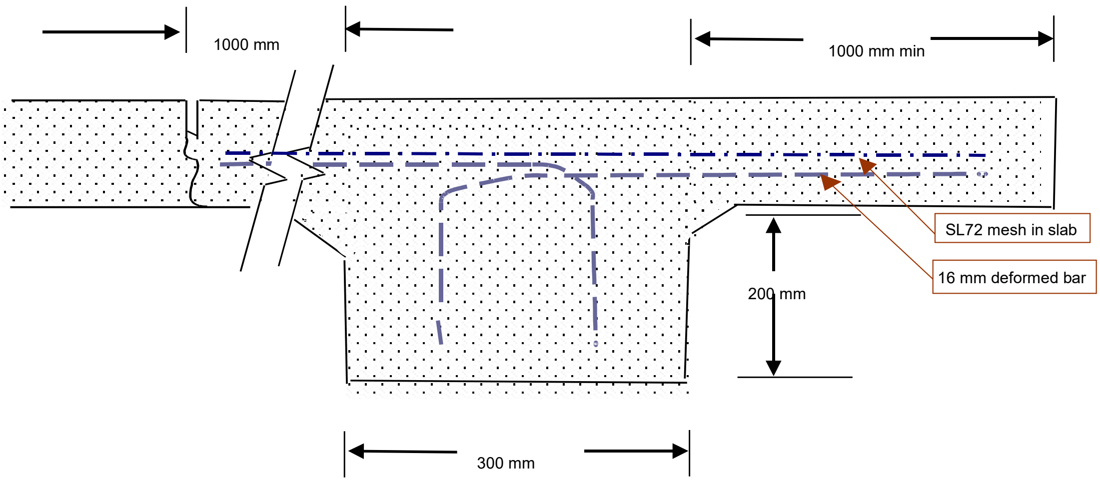
b) Anchor blocks

i) Where the slope of the path exceeds 5%, the use of anchor blocks should be considered to prevent slippage of the slab.

ii) The blocks comprise a beam of concrete typically measuring 200 mm high by 300 mm wide cast integrally and transverse to the path.

iii) For longer slopes, a spacing of about 40 m between blocks is recommended. When the anchor block is cast at the end of the path it is often referred to as a terminal block as shown in Figure 4-5.

Figure 4-5 Terminal block detail



iv) Additional reinforcement (deformed bars) to the slab mesh is placed in the slab and anchor block to prevent transverse cracking at the leading edge of the anchor block.

c) Reinforcement

i) Continuous steel mesh reinforcement is required for the concrete bikeway designs in Table 3-14. The recommended mesh size is SL82 with 200 mm overlaps (one mesh row) on adjoining sheets.

ii) Reinforcement should be placed on bar chairs at the mid point or within the upper half of the pavement slab for effective crack control. A minimum top cover of 40 mm is required for pavements less than 150 mm thick, and 50 mm cover for slabs greater than or equal to 150 mm. The use of broken bricks etc. to support reinforcing steel is unacceptable.

iii) Reinforcing is also used for anchor blocks and vehicle crossovers as previously discussed.

d) Surface finish

i) Surface finishes produced from a hessian drag, wooden float or light broom should provide sufficient skid resistance for bicycles.

ii) On shared paths, other finishes such as a stamped or coloured surfacing can be used for delineation.

e) Curing

i) Curing of the concrete involves ensuring that adequate moisture is available for hydration of the cement, which is essential for the development of concrete strength and durability.

ii) Methods of curing include sealing the surface or continual dampening with a fine water spray. However, other curing options set out in Master Specification Part ST-SC-C7 “Placement of Concrete” are also practical and effective.

4.7 Concrete block paver construction

The performance of CBPs is very dependent upon the specification of the paving units and the manner of their construction. The Concrete Masonry Association of Australia (CMAA 1997c) has produced a detailing guide, which provides comprehensive specification and construction information. Consideration of the following apects should ensure good long-term performance of CBP bikeway:

a) CBP thickness: 60 mm or 80 mm bedding and joint filling material;

b) selection of shape types: fully, partial or non-interlocking units;

c) laying pattern;

d) selection and detailing of the edge restraint system;

e) edge pattern/treatment of CBPs;

f) detailing of the transitions between paving types;

g) bedding course drainage; and

h) detailing around utility pits.

4.8 Drainage

4.8.1 Surface drainage

a) Good drainage is critical in the design of roadways, paths and tracks. In addition to the safety and convenience of bikeway users, the drainage design will contribute significantly to the structural performance of the pavement.

b) Uncontrolled flow of surface water can cause severe erosion of unsurfaced pavements and side channels, and undermine the unprotected edges of sealed bikeways. It is essential to prevent the ponding of surface water that may infiltrate the base of the path and weaken the pavement structure. Water should be drained by adequate surface crossfalls (refer Austroads (2017) Guide to Road Design Part 3 Geometric Design) and side channels into the storm water system.

c) The subgrade should also be constructed with these crossfalls to allow free drainage of pavement layers, without depressions that may hold water and weaken the substrate.

4.8.2 Subsurface drainage

a) In localised areas subject to springs, seepage flows, or excessive irrigation, the construction of a subsurface drain may be required to preserve the soil strength of the bikeway subgrade. The cost and complexity of installing good subsurface drainage systems means that they need to be both warranted and well engineered. In South Australia, situations requiring this treatment tend to be relatively uncommon.

b) Design of subsurface drainage for road pavements is detailed in Austroads (2009c) Guide to Pavement Technology Part 10 Subsurface Drainage). Manufacturers and suppliers of prefabricated geo-composite drainage products also provide technical design and installation information in their promotional literature.

4.9 Vegetation

4.9.1 Pavement damage considerations

a) Landscaping issues for bikeways are usually associated with the geometric design and aesthetics of the facility. However the damaging effect of vegetation can be substantial.

b) Spraying the path and a strip to either side with a suitable weedkiller prior to construction, and the use of permanent edge restraints and grass trimming, are usually necessary to adequately control weed and grass invasion.

c) In pavements constructed on heavy clay soils (PI greater than 30), the most pronounced movement occurs near trees and shrubs as a result of soil moisture losses during dry periods. Both small and large tree species can cause surface shape loss and cracking. The following factors may influence the extent of such damage:

   i) mature height of the tree;

   ii) mature canopy width;

   iii) species type;

   iv) plantation density,

   v) soil characteristics; and

   vi) planting techniques.

d) Species that grow rapidly and are vigorous in their search for moisture can cause large deformations in expansive soils.

e) Wherever possible trees and shrubs should be set back a distance equating to the greater of 1½ times the mature height or twice the mature canopy width of the tree.

f) If it is impractical to provide adequate clearance between trees and the bikeway, then construction of root barriers or inclusion of reinforcement in concrete bikeway slabs adjacent to trees should be considered to reduce the extent of cracking.

g) Planting techniques that encourage deep root growth, rather than lateral growth towards the bikeway, may also minimise pavement damage. Common techniques include:

   i) deep ripping prior to planting to break up heavy soil; and

   ii) regular and thorough watering during the establishment period (first 1 to 2 years).

h) Barry (1986) provides a limited list of potentially suitable trees and shrubs for plantations on expansive clay soils.

4.10 Construction of service crossings

a) Installation of services should be undertaken prior to bikeway construction.

b) Services installed after bikeway construction should be installed through a jacked sheathing culvert.

c) If narrow and/or deep trenches are excavated across the bikeway, it may be necessary to reinstate with a flowable-fill material to avoid long-term settlement. These materials are available from ready mixed concrete suppliers as Controlled Low Strength Materials (CLSM) and comprise a sand, cement, flyash and water mixture that is flowable, self-levelling and does not require compaction. Various strength mixes are available, and 0.7 MPa mixes are typical for subgrade reinstatements (Transport SA 1997).

d) Open trenching across a bikeway requires the following:

   i) sawing of the surfacing;

   ii) replacement and thorough compaction of all back-fill from the service asset to the top of subbase level using a subbase quality material;

   iii) reinstatement of the base and surfacing layers in materials equivalent to the original;

   iv) replacement and dowelling of concrete slabs to preserve shear load transfer; and

   v) for thin asphalt surfacings an additional 50 mm thickness of asphalt.

5 Maintenance

5.1 Maintenance of bikeways

5.1.1 General requirements

a) Bikeway pavements can be maintained using many of the practices associated with conventional road pavement types. Austroads (2009g) Guide to Pavement Technology Part 7 Pavement Maintenance provides further information on road pavement maintenance which supplements the discussion of bikeway maintenance issues within this Guide. Austroads (2009g) Guide to Pavement Technology Part 7 Pavement Maintenance also includes links to a number of useful technical notes, pavement work tips and other publications provided by Austroads, Austroads member organisations and industry associations.

b) Smooth, debris free surfaces are a fundamental requirement for cycling safety. Most bicycles have no suspension or shock absorbers and many have relatively thin tyres inflated to high pressures. As some bikeway cyclists travel at speeds of around 30 km/h on flat grades and up to about 50 km/hr on downhill grades, a rough surface or pothole can be particularly hazardous. Regular maintenance activities on bikeways should include (Austroads (2021) Guide to Road Design Part 6A Paths for Walking and Cycling such as:

   i) filling of cracks;

   ii) patching of potholes

   iii) trimming or removal of grass so that it does not intrude into the path;

   iv) 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);

   v) repainting of pavement markings;

   vi) cleaning of signs; and

   vii) trimming of trees and shrubs to maintain safe clearances and sight distances.

5.1.2 Pavement surface tolerance

Austroads (2021) Guide to Road Design Part 6A Paths for Walking and Cycling advises that bikeway surfaces should be within the tolerances given in Table 5-1.

Table 5-1 Existing surface tolerances

Location of tolerance[a]	Not to exceed (mm)	
	Width of groove	Height of step
Parallel to direction of travel	12	10
Perpendicular to direction of travel	-	20

Table notes:

a) Source: Caltrans (1995)

5.1.3 Drainage

a) The gradual deterioration of the drainage system often manifests itself in other faults and distress patterns on the bikeway, which in turn can become the focus of a more comprehensive and expensive maintenance effort.

b) Drainage maintenance mainly requires the provision of:

   i) adequate bikeway surface crossfall, either one way or two way with crown; and

   ii) maintenance of verges and immediate surrounds of the bikeway to clear grass and other debris from culverts and drainage paths and ensure good surface runoff.

c) Due to its importance in the prevention of more severe distress, drainage systems warrant regular monitoring and timely intervention.

5.1.4 Crack filling

a) Crack-filling is undertaken to seal the underlying pavement layers from moisture ingress and prevent strength loss or swell in these materials. Cracks appearing as fractures in the surfacing are difficult to fill without forming a profile extending proud of the surface.

b) Crack sealants are normally bituminous compounds, and are modified with polymers or ground rubber for active cracks, and finished with 2mm grit to provide skid resistance. Excess grit should be removed to minimise the hazard to cyclists.

c) Crack filling using epoxy or urethane is sometimes undertaken on concrete pavements; refer to TfNSW QA Specification 3204 Preformed Joint Fillers for Concrete Road Pavements and Structures.

5.1.5 Resurfacing

a) Resurfacing restores the function of the original surfacing and could be undertaken to waterproof the base layers, upgrade skid resistance, or improve the shape and riding quality of the bikeway.

b) The treatment options generally comprise thin flexible bituminous treatments, but over concrete and block pavers these are likely to reflect the jointing pattern. The most appropriate resurfacing treatments for bikeway pavements generally include:

   i) sprayed reseal - a modified binder may be used to improve the resistance to crack reflection. Paving fabric may also be placed for crack interception and additional waterproofing.

   ii) microsurfacing - this can be used to correct minor surface irregularities.

   iii) asphalt overlay - can be used for shape correction. Modified binder may improve resistance to crack reflection, but little performance data is available for bikeways.

c) Other restorative treatments are available for sealed surfaces that are structurally sound, but have an excess or lack of bituminous binder. These comprise the softening and addition of additional aggregate to the surface (for binder excess) and enrichment treatments for binder deficit.

d) Some asphalt types, such as stone-mastic asphalt and open-graded asphalt (Foley 2001) appear to be able to resist the reflection cracking occurring in road pavement surfacings better than others.

e) Further detailed information regarding sealing and restorative treatments may be obtained from Austroads (2009d) Guide to Pavement Technology Part 3 Pavement Surfacings.

5.2 Maintenance considerations

5.2.1 Flexible pavements

a) Unsealed surface

   i) Unsealed or gravel surfaces rely on the cohesion and grading of the soil particles to maintain a hard and durable surface. The critical maintenance activities for these surfaces are usually related to drainage and include:

      A. maintaining an adequate surface crossfall, either one way or two way with crown;

      B. ensuring that grass and other debris does not build up along the pavement margin; thereby preventing surface runoff;

      C. checking and clearing culverts and drainage paths;

D. reshaping to eliminate any low points, potholes etc.; and

E. periodic resheeting to preserve base thickness and shape.

b) Spray sealed and thin asphalt surfaces

i) The waterproofing of the base material by the surfacing treatment minimises or eliminates some of the maintenance tasks associated with an unsurfaced pavement. To preserve the integrity of this surfacing it is important to-

A. repair any discontinuities that allow water to pond and/or penetrate into the base course;

B. maintain the margin of the surfacing edge support and waterproof or crackseal any gap that occurs;

C. prevent the verge vegetation from encroaching onto and penetrating the asphalt or seal; and

D. maintain the general drainage efficiency of the bikeway and environs as described for unsealed surfaces.

ii) The condition or amount of binder at the riding surface may sometimes require an intervention treatment.

iii) Too much bitumen on the surface usually results in bleeding or slickness when the aggregate particles become deeply embedded or at times enveloped in a bitumen film. The loss of aggregate and skid resistance can become a safety issue for bikeway users.

iv) Loss of bitumen binder from the surface (or hardening) can lead to stripping of the seal and ravelling of asphalt, reducing the ability of the surfacing to act as an effective moisture barrier for the underlying granular base. Variable skid resistance and eventually potholing often results. Binder loss may primarily be due to the age of the bitumen, oxidation, and exposure to sunlight. The lighter fraction of the bitumen tends to evaporate leaving the heavier and more brittle bitumen components that have a less tenacious grip of aggregate particles.

v) Methods of repair of bleeding, flushing, binder embrittlement, stripping and ravelling are contained in Austroads (1991) Road Maintenance Practice 2nd Edition and ARRB (2020 Sealed Roads – Best Practice Guide 3 ARRB Group).

c) Asphalt surfaced pavements

i) If specific edge restraint to the top of the asphalt layer is not provided, some lateral support to reduce the occurrence of edge breaks may be achieved by topping up and maintaining the adjoining surfaces or shoulders of the bikeway.

ii) Treatment of ravelling and bleeding of the surface may also be required.

5.2.2 Rigid pavements

Most maintenance activities associated with concrete pavements relate to the joints, where spalling of the concrete arris, step-faulting or other vertical discontinuities may occur.

a) Spalling

i) Spalling occurs when joints become blocked with incompressible particles and are unable to relieve the high thermal expansion stresses by slab movement. Low concrete strength (and durability) also tends to result in concrete spalling where edges or joints are trafficked by vehicles.

ii) Repair of spalling at slab joints is difficult, as any cementitious repair should not extend across the joint. As this can be a labour intensive task, spalls are often treated with flexible filler such as fine 5 mm size asphalt. However, this type of treatment would impact adversely on the aesthetics of the bikeway.

b) Faulting

i) Step-faulting and other vertical misalignment across joints occurs when tree roots or swelling soils cause localised heave or subsidence of a slab. This can require milling of the step or replacement of slabs in severe cases.

ii) Heavy commercial vehicle loadings may also fracture individual slabs requiring an appropriately designed repair.

c) Slab jacking

i) This technique is used on concrete roads where the relative movement between adjacent slabs is substantial. A fine cementitious grout or 'mud' ('mud jacking') is injected to level adjoining slabs. For bikeway pavements, slab replacement is likely to be a better option where this type of distress occurs.

ii) As for all other pavement types, attention to drainage is important. Settlement of slabs in a poorly drained section of concrete bikeway also requires correction of the drainage problem. Slab jacking will only be effective while the underlying subbase or subgrade is protected from further erosion and subsequent settlement.

d) Cracked slabs

i) Slabs that have cracked and appear stable (no spalling or pumping etc.) should be monitored, as the bikeway traffic loading may not require slab replacement.

ii) For unreinforced concrete and/or wide cracks, crack-sealing using a flexible bituminous sealant should be considered, with the performance risks of not waterproofing the crack weighed against the loss in ride quality.

5.3 Safety during works

Maintenance and construction operations should be undertaken so that the safety of workers, cyclists, and other users remains at an acceptable standard. Austroads (2014b) Guide to Pavement Technology Part 4B Asphalt and Austroads (2017c) Cycling Aspects of Austroads Guides) provides comprehensive recommendations on the signing and delineation of works.

5.4 Monitoring

5.4.1 Surface shape

a) Roughness

i) Pavement surface can be assessed by roughness which is a measure of the ride quality or smoothness of a pavement surface.

ii) It is the cumulative variations in longitudinal profile are measured to assess the ride quality, for determining network performance and prioritising maintenance activities.

iii) It is primarily reported in:

A. NAASRA Roughness Meter counts (nrm, c/km); or

B. International Roughness Index (IRI, m/km)).

iv) IRI units are common overseas and for comparison with nrm, a reasonable correlation has been determined by Prem (1989) as:

A. nrm (c/km) = 26.5 x IRI – 1.27

v) Roughness is measured by-

A. laser profilers are the most common for Australian road pavements, operating at speeds above 30 km/h and providing test results in both IRI and NAASRA counts;

B. NAASRA Roughness Meter, which comprises a sensor, mounted on the rear axle of a standard vehicle. This has been virtually superseded by laser profilometry. The slowest calibrated test speed is normally 50 km/hr; and

C. ARRB walking profiler, which measures pavement surface roughness as it is pushed along at walking speed. While it can access very narrow paths, it is relatively slow and is more suited to high precision small area applications.

vi) Roughness values of less than 40 NAASRA counts/km on the road network are considered very smooth and typical of good quality new pavement. Users tend to find roughness levels up to 110 nrm acceptable, particularly for speeds of less than 80km/hr.

vii) Roughness measurements greater than 150 nrm usually require some intervention treatment to reduce the roughness. The 110 and 150 nrm levels typically define the broadly accepted terminal roughness values for rural main roads or highways and the main urban arterial road alignments.

viii) There appears to have been little if any development work to determine an appropriate terminal condition or intervention level for bikeway roughness. However, roughness measurements on existing facilities could be used in conjunction with user feedback to initially develop these values. Alternative interim limits could be based on those associated with road pavements, as these roughness standards are imposed on cyclists using the normal road network.

ix) Typical Department requirements for the mean maximum NAASRA lane roughness for each 100 m section of new road pavement construction are:

A. 50 c/km for speed zones of less than or equal to 70 km/h; and

B. 40 c/km for speed zones greater than 70 km/h.

x) This standard of construction is unlikely to be achievable for most bikeway constructions and there is some user survey data to indicate that higher roughness is acceptable. Interim initial roughness values for bikeways are suggested in Table 5-2, with recreational and commuter facilities providing convenient category definitions.

Table 5-2 Suggested maximum average initial roughness per 100m length

Recreational bikeways	Commuter bikeways, (and high standard applications)
100 counts/km	75 counts/km

b) Local pavement shape variability

i) Pavement surfaces can also be assessed by local shape variations which are primarily measured by manual means for the quality control of construction and rehabilitation treatments.

ii) These can be related to:

A. rutting, wheelpath deformation from vehicle loads;

B. pavement edge drop-off;

C. surface irregularities associated with tree roots or soil movements; and

D. step faulting of concrete slabs.

iii) Shape is usually measured as a deviation in millimetres from a 1.2 m or a 3.0 m length straight edge, and is often part of rating systems commonly in use. Refer also to Table 5-1, Table 5-4 and Table 5-5.

5.4.2 Skid resistance

a) The skid resistance of Australian pavements is generally measured as a friction number or coefficient:

i) Grip Number determined from the GripTester: continually measured by a towed device, which can also be pushed by hand in narrow areas.

ii) British Pendulum Number (BPN): measured by the British Pendulum (BP), a portable device which tests a small and discrete area of surface; and

iii) Sideways Force Coefficient (SFC): continually measured with a device known as SCRIM (mounted on a heavy commercial vehicle) but test speeds of 50 km/hr and significant clearance requirements generally exclude the use of this equipment on bikeways.

b) All three devices measure the skid resistance of the wet surface.

c) Testing of bikeway skid resistance at a network level is uncommon and is more likely to be required for the assessment of local problems. These may be due to surface polishing, contamination or where the texture is substandard. The most appropriate testing device would be the British Pendulum or GripTester. A minimum Grip Number of 0.40 is recommended for Bikeways.

d) Investigatory levels for road pavement surfaces recommended by the Department are indicated in Table 5-3.

Table 5-3 Recommended investigatory levels for skid resistance

Road Situation	Minimum Grip No.[(a)]	Maximum vehicle speed km/h
Difficult sites – steep grades, tight bends, traffic signal approaches, roundabouts	0.50-0.55	60-80
Urban arterial roads	0.45	60
Rural arterial roads	0.45	110
Urban/lightly trafficked/bikeways	0.40	60

Table notes:

a) The approximate conversion from British Pendulum No. to the Grip No. is Grip No.= 0.01x BP

5.4.3 Cracking and other surface irregularities

Cracking and other pavement defects may be assessed for bikeways. Austroads (2019b) Guide to Pavement Technology Part 5 Pavement Evaluation and Treatment Design and ARRB (2020) Sealed Roads – Best Practice Guide 3 ARRB Group) provide examples of these distress types for flexible and rigid pavements.

5.4.4 Rating systems for paths

a) Pavement asset management systems usually rate condition indicators such as roughness, rutting, and skid resistance, by collecting data automatically at normal motor vehicle speeds. Estimates or measurements of cracking, potholing, texture and strength, may also be undertaken.

b) Only a few of these parameters would normally be measured or assessed for bikeways, generally by means of a pavement inspection.

c) The Department of Urban Services, Canberra (Robinson et al. 2001) has developed rating categories for concrete and asphalt 'community paths' as summarised in Table 5-4 and Table 5-5.

Table 5-4 Concrete paths rating system (DSS 1998)

Rating	Description
Poor	Extensive cracking of the pavement; concrete is loose, spalling, broken or subsided. Large (> 10 mm) wide cracks with vertical displacement (i.e. step > 25 mm). Severe ramping of the pavement (typically two bays of path uplifted to form a peak at the joint line).

Rating	Description
Fair	Large (> 10 mm) cracks with horizontal displacement of concrete producing a step of < 25 mm. Ramping < 30 mm. Generic comment: A fair to poor pavement is reached where maintenance intervention is required to preserve the asset and/or ensure public safety.
Good	Fine to medium cracks < 10 mm in width in width and single longitudinal cracking with little or no vertical displacement. Ramping < 30 mm. Generic comment: A good condition is where the pavement has not deteriorated to extent that maintenance work is deemed to be essential, for reasons of public safety and/or asset preservation.
Excellent	New paths and hairline cracks.

Table 5-5 Asphalt paths rating system (DSS 1998)

Rating	Description
Poor	Longitudinal and transverse cracking width > 10 mm. Extensive, concentrated crocodile-like pavement cracking. Continuous lengths of weed infested pavement generally located along the path edge in combination with pavement failure. Rippling (height > 20 mm) typically due to tree root damage of the pavement resulting in poor riding conditions. Eruptions (height > 20 mm) typically due to tree root intrusion or base course chemical reaction.
Fair	Longitudinal or transverse cracking of the wearing surface (< 10 mm) Rippling of wearing surface or eruptions < 20 mm. Patches as distinct from continuous lengths of weed infested pavement, generally located along the path edge, in combination with pavement failure. Isolated patches, as distinct from continuous areas of crocodile like surface cracking. Generic comment: A fair to good pavement condition is reached where maintenance intervention is required to preserve the asset and/or ensure public safety.
Good	Paths with a satisfactory ride quality (deviation from a 3 m straight-edge not exceeding 5 mm at any point). Minor surface deterioration not requiring maintenance intervention. Generic comment: A good condition is where the pavement has not deteriorated to the extent that maintenance work is deemed to be essential, for reasons of public safety and/or asset preservation.
Excellent	New paths.

5.4.5 Intervention treatments

Table 6-1 to Table 6-4 (from Robinson et al. 2001) in Appendix 1: Proposed intervention treatments suggest treatments for a range of distress modes for gravel paths, asphalt paths, paver-surfaced paths and concrete paths. Table 6-2 has been modified from the original reference to include spray sealed and slurry surfaced bikeways. The recommended treatments provide some additional detail for repair strategies for bikeway pavements.

6 Appendix 1: Proposed intervention treatments

Table 6-1 Proposed intervention treatments for gravel paths[1]

Defect	Comments and treatment [(a)]
Erosion of the path	Redirect the water flow where possible. There is a requirement to fill any areas of erosion with additional gravel. Stabilising the gravel with lime may also be required.
Loose surface	This may require the gravel to be stabilised with lime at 2% by volume.
Water ponding	Place additional gravel to ensure water runs off the path.
Grass on the path	Spray the path with weed killer and chip weeds where required.

Table notes:

(a) Path used for pedestrians, cyclists and other users.

Table 6-2 Proposed intervention treatments for asphalt paths

Defect	Comments and treatment
Crack width less than 3 mm	No action
Crack width between 3 mm and 10 mm	These cracks do not present a problem to the user unless the pavement lifts, causing pedestrians to trip. These can be filled with a crack filling material, but care must be taken to ensure that the product does not leave a slippery surface (longitudinal cracking only). Extensive cracking may require the surface to be replaced.
Cracks wider than 10 mm	These cracks can cause pedestrians to trip, and cycles, wheelchairs and strollers to be thrown off course. These cracks must be filled to remove the hazard. Coldmix may be able to be used, a modified crack filling material may be appropriate or the surface may need replacing.
Cracking from vehicles (no displacement)	No action.
Substantial cracking, shoving and surface breaking up	Remove surface, recompact base material and replace asphalt, sprayed seal or slurry surfacing.
Trench subsidence below 8 mm	No action unless ponding is a problem.
Trench subsidence over 8 mm	Remove surfacing in the affected area, re-level the base and replace asphalt, sprayed seal or slurry surfacing.
Sharp subsidence/uplift and dangerous bumps	Remove surfacing in the affected area and replace, removing the subsidence/uplift. Where this is resulting from tree root intrusion, remove root.
Sulphate attack	Remove surfacing and base and relay a new base and asphalt, sprayed seal or slurry surfacing. The alternative to this is to mix lime with the base material and then place the new surfacing.
Potholes	Fill pothole with coldmix.
Water ponding	Drain the bikeway where possible by removing soil from the side of the path to allow water to escape. Where this is not practical, a section of the bikeway may need to be replaced or overlayed.
Deterioration of surface with age	Replace the surface or overlay the bikeway with asphalt, slurry or sprayed reseal.

Table 6-3 Proposed intervention treatments for [concrete] paver paths

Defect	Comments and treatment
Displacement below 8 mm	No action.
Displacement greater than 8 mm	Remove pavers, level and compact the base and relay the pavers. Where the pavers are stuck to the base, it may require grinding of the pavers to provide a level surface.
Subsidence/uplift below 8 mm	No action.

Defect	Comments and treatment
Subsidence/Uplift of individual pavers greater than 8 mm	Remove pavers, fix base and relay the paver.
Constant slope below 25 mm in 1m	No action.
Constant slope towards centre of subsidence/uplift greater than 25 mm in 1 m	Remove the pavers, install additional base material, compact and relay the pavers in the subsided area. Where tree roots cause the problem, either remove the root or reduce the slope of the ramp.
Cracked pavers	Where the paver is cracked and not moving - no action.
Missing pavers	As a temporary repair fill with sand or gravel, install a new paver.
Gaps between pavers	Narrow gaps between pavers may be filled with sand. Larger gaps may require additional sections of pavers to be placed in the gaps.
Slippery surface of pavers	Slippery paver surfaces may be ground to remove the slippery surface. Glazed tiles are normally slippery when wet and should be avoided as much as possible. Removal is the best solution.

Table 6-4 Proposed intervention treatments for concrete paths

Defect	Comments and treatment
Vertical displacement below 8 mm	No action.
Vertical displacement between 8 mm and 25 mm	The step should be removed by grinding or ramped with coldmix asphalt.
Vertical displacement greater than 25 mm	Localised displacements on sections in good condition should have a coldmix asphalt ramp installed
Joint/crack widths below 8 mm	Extensive areas of displacement, in areas of trees, cut roots, install root barrier and replace concrete or regulate with asphalt.
Joint/crack widths between 8 and 20 mm	If severe damage caused by vehicles that are unable to be kept off the path, replace concrete to comply with this Guide including steel mesh.
Joint/crack widths greater than 20 mm	No action.
Skid resistance problem	Individual cracks can be filled with grout.
Ponding of water	Extensive cracking of the bikeway requires replacement, refer Section 3.6, and include steel mesh.

7 Appendix 2: Technical basis for bikeway designs

This Appendix contains a summary of the technical basis for the development of data in Table 3-5, Table 3-6, Table 3-7, Table 3-11, Table 3-12, Table 3-13 and Table 3-14.

7.1 Subgrade strengths

Subgrade strengths have been selected at CBR values of 2%, 5% and 10% to represent Low Strength, Moderate Strength and High Strength founding conditions respectively.

7.1.1 Low strength (design CBR 2%)

a) Given the likely location of bikeways in zones of low-bearing soils (e.g. paths meandering around river flats/plains, amongst seasonally watered vegetation/gardens, and the relatively narrow structural width of the bikeways themselves, which expose them to a relatively greater moisture ingress than road pavements), this low (2%) value is considered suitable.

b) In addition it would be less likely for these facilities to have a stabilised foundation (subgrade) as compared to road pavements. Thus, while most design charts for roads commence at a design CBR of 3%, this lower value of 2% is considered prudent

7.1.2 Moderate strength (design CBR 5%)

This represents an often-used design value for reasonably sound bearing soils.

7.1.3 High strength (design CBR 10%)

Austroads presumptive CBR design values for the range of common soil types have an upper limit of 15% for well graded sands with excellent drainage. Wherever possible, the Department undertakes a thorough investigation of support conditions and generally adopts an upper limit of CBR 10% to characterise road and bikeway pavement subgrades.

7.2 Traffic loading

7.2.1 Pedestrian and bicycle traffic only

This loading represents the uncommon case of nil maintenance (or other) vehicles that are substantially heavier than pedestrian or bicycle loadings (typically a maximum unit mass of about 100 kg), and cannot be equated to any units of ESA (flexible pavement) or HVAG (rigid pavement).

7.2.2 Heavy vehicles

a) The minimum pavement design listed in sections 3.5 and 3.6 are appropriate for heavy vehicle loading of an (average) weekly one-way passage of a two-axle rigid truck with the following loads:

   i) 5 tonne (49.0 kN) single axle single tyre (SAST); and

   ii) 7 tonne (68.6 kN) single axle dual tyres (SADT).

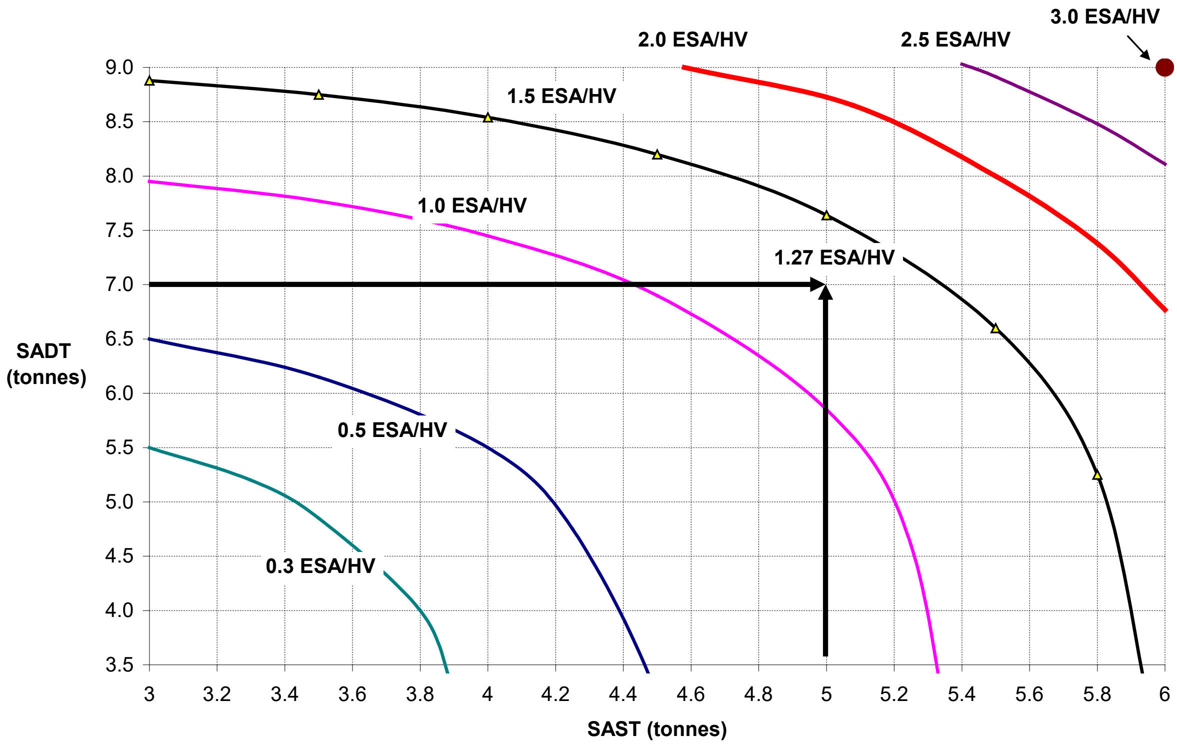
b) These loads would are considered typical of a road-patrol truck with gross mass (12 tonne), which is about 80% of the maximum prescriptive gross mass.

c) For the design of flexible pavements using the empirical design chart (Figure 12.2 Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design), the cumulative number of Equivalent Standard Axle (ESA) over the Design Life is required. This design number of ESA is abbreviated to DESA in Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design).

d) The cumulative number of truck repetition over the 20 year Design Life is about 1040 (20 years x 52 weeks x 1 vehicle/week). However because of the restricted width of bikeways compared to roads, the loading is more channelised and hence the number of load repetitions is multiplied by a factor of 3 (TRL 1996). Hence the minimum pavement designs have been based on 3 x 1040 = 3120 truck repetitions.

e) Using equation 7.3 of Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design), the ESA of damage due to 5 tonne single steer axle (SAST) is 0.73 ESA and for the 7 tonne single drive axle (SADT) is 0.54. Thus each pass of the 12 tonne rigid truck causes a total of 1.27 ESA of damage. Figure 1-1 allows the ESA of loading to be calculated for other axle group loads.

Figure 7-1 ESA of loading due to a single pass of two-axle rigid truck



f) Hence the minimum flexible pavements designs are appropriate for a design traffic loading of DESA = 3120 x 1.27 = 3960, this figure has been rounded to 4000 ESA in this Guide.

g) Design traffic in terms of Heavy Vehicle Axle Groups (HVAG) is required for the design of rigid pavements. Over the 40 year Design Life there are 1.2 x 104 HVAG (40 years x 52 weeks x 1 vehicle/week x 2 axles/ vehicle). For simplicity this, is expressed as 6000 truck repetitions in this Guide.

7.3 Minimum pavement configuration

a) Minimum pavement configurations are given in this Guide for the above-mentioned design traffic loading. If the bikeway is likely to sustain more frequent or heavier axle loadings, it is recommended that the bikeway pavements be design using Austroads (2024) Guide to Pavement Technology Part 2 Pavement Structural Design). However, because of the restricted width of bikeways compared to roads, the loading is more channelised. Hence the DESA calculated using Austroads needs to be multiplied by a factor of 3 (TRL 1996).

b) For concrete bikeways on which the loading is limited to 2-axle rigid trucks, a simplified design procedure is provided in Appendix 3: Thickness design of concrete bikeways.

8 Appendix 3: Thickness design of concrete bikeways

a) The minimum concrete designs given in Table 3-14 are applicable for 6000 load repetitions of a 2-axle rigid truck with a maximum load of 7 tonnes on the single axle dual tyre (SADT) For the purpose of developing the minimum concrete thickness designs given in Table 3-14, it is assumed that the truck steer axle (SAST) does not cause fatigue damage to the concrete provided that the axle load does not exceed the legal limit of 6 tonnes. However, fatigue from all required axle group combinations must be assessed in accordance with the procedure give in Section 12.9 of Austroads (2024) Guide to Pavement Technology Part 2 Asphalt Structural Design.

b) Where a higher number of load repetitions or SADT load exceeding 7 tonne is expected, the following procedures may be used to determine the required thickness of concrete base.

c) Using the procedures in Section 12.9.3 of Austroads (2024) Guide to Pavement Technology Part 2 Asphalt Structural Design), calculate the equivalent subgrade CBR. Where 100 -150 mm of granular subbase (min CBR = 15%) is provided under the concrete base, Table 8-1 lists the equivalent subgrade CBR values for a range of subgrade CBRs.

Table 8-1 Effective subgrade CBR values

Subgrade Design CBR (%)	Granular subbase thickness (mm)	Equivalent Subgrade CBR (%)
2	150	3
3	150	4
5	150	6
7	150	8
10	100	10
15	100	15

d) The expected number of 2-axle rigid truck load repetitions over the Design Life is then calculated. For example, if one truck pass per month is expected over a 40 year Design Life the number of repetitions is:

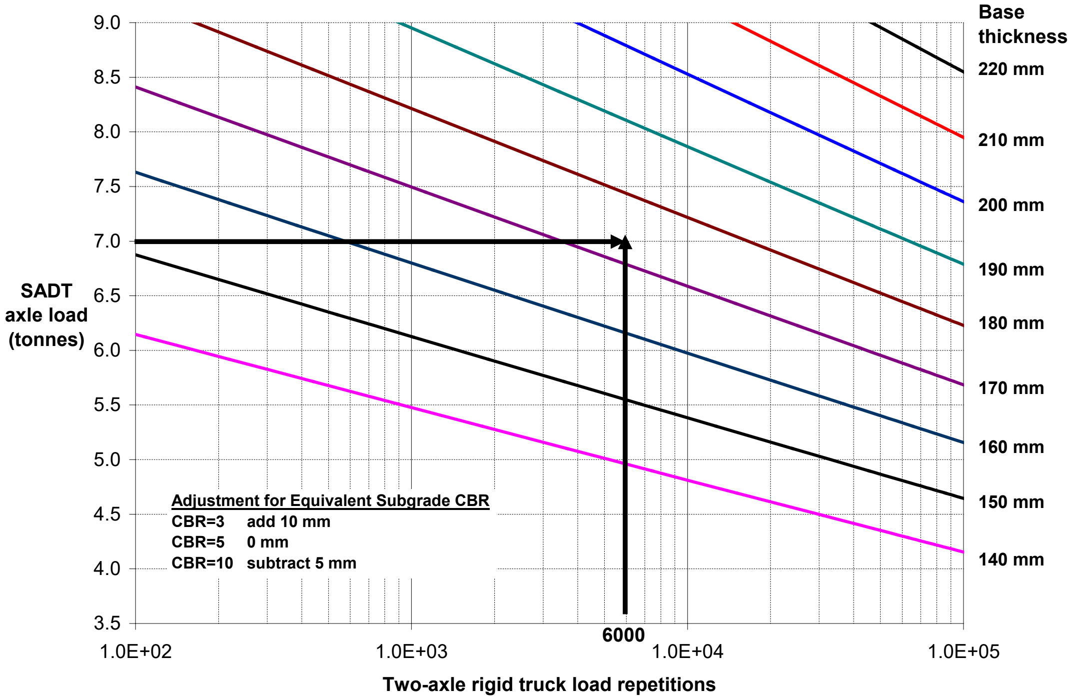
i) Ntrucks = 12 (months) x 40 (yrs) x 1.0 (truck/month) x 3.0 = 1440 load repetitionsn

e) The maximum expected load on the SADT axle group needs to be estimated. This is the design SADT axle load.

f) Using the equivalent subgrade CBR, the expected load repetitions of the design SADT axle load, the required thickness of base is calculated using Figure 8-1. Note that the thicknesses in Figure 8-1 includes a 10 mm construction tolerance. This tolerance is appropriate when bikeways are constructed in accordance with Master Specification Parts. Where other specifications are used, consideration needs to be given to adjusting Figure 8-1 thicknesses.

g) As discussed above, the minimum concrete designs given in Table 3-14 are applicable for 6000 load repetitions of a 2-axle rigid truck with a maximum load of 7 tonnes on the single axle dual tyre (SADT). Figure 8-1 indicates that the required base thickness for this loading is 175 mm, assuming that the 10 mm construction tolerance is appropriate.

Figure 8-1 Concrete base thickness (include 10mm construction tolerance)



h) The recommended pavement type for bikeways is a continuous lapped SL82 mesh, with transverse contraction joints saw cut at 4.0 m centres to depth = D/4 and expansion joints to be installed every 5th contraction joint.

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