Government of South Australia
Department of Planning, Transport and Infrastructure

Safety and Service Division
Pavement Design

Supplement to the
Austroads Guide to Pavement Technology
Part 2: Pavement Structural Design

FOREWORD

The purpose of this Supplement is to provide more specific procedures and direction when using the Austroads methodology for the design of new pavements for the DPTI, Safety and Service Division.

This document is intended to act as a supplement to the Austroads publication *Guide to Pavement Technology Part 2: Pavement Structural Design* (2012). The Supplement reflects current knowledge and experience of the performance of South Australian pavements. In addition, it draws on the experience of other state road authorities, as documented in their Guide supplements.

The use of the term "Guide" in this document refers to the Austroads *Guide to Pavement Technology Part 2: Pavement Structural Design*, while the term "Supplement" refers to this Safety and Service Division Pavement Design Supplement.

The section numbers and figures in the Supplement refer to those published in the Guide except where new sub-sections and figures have been added sequentially and numbered accordingly. A sub-section that is not included in the Guide is indicated in the Table of Contents by an asterisked (*) heading.

Users of this Supplement should confirm that all revisions have been included.

REVISION RECORD

First published December 2006 as a Supplement to the 2004 Austroads Guide to the Structural Design of Road Pavements AP-G17/04.
Second Edition published December 2009 as a Supplement to Austroads AGPT02-08.
Third Edition published August 2012 as a Supplement to Austroads AGPT02-12.
Fourth Edition published October 2014 as a Supplement to Austroads AGPT02-12.

Summary of key Fourth Edition Revisions

Revision Date	Updated Pages	Comments
October 2014	P10, §3.7e)	Replace AC20HB with AC14HB
	P10, §3.7g)	Amend high bitumen asphalt layer thickness
	P10, Table 3.1	Update Typical As Constructed Thicknesses
	P12, Table 3.3	Updated Asphalt Types
	P26, Table 6.18	Updated Asphalt Mixes
	P41, §11.1.1	Note re 20mm level tolerances on subgrade
	P42 Table 11.1	Amended Subgrade Level Tolerance
	P44 Table 11.3	Amended Design Levels and Level Tolerances

Contents

* indicates additional sub-section to Austroads Guide Part 2

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1 INTRODUCTION

1.1 Scope of the Guide

Chapter 12 of the Guide describes procedures for the design of lightly trafficked pavements. Whilst this Supplement may not in all areas specifically address such pavements, the majority of the documented recommendations and requirements are also applicable to lightly trafficked pavements. Engineering judgement and appropriate risk management practices should be used to determine where the design requirements for lightly trafficked pavements differ from those for moderately and heavily trafficked pavements.

Construction of pavement designs shall comply with the DPTI Master Specification for Roadworks.

2 PAVEMENT DESIGN SYSTEMS

2.2 Common Pavement Types

2.2.1 General

For moderately and heavily trafficked roads, the following pavement configurations are constructed by DPTI:

Rural roads

- Unbound granular pavement with sprayed seal surfacing - extensively used due to their low cost. The quality required for the base layer is dependent on the traffic loadings. Where horizontal shear stresses are high due to turning traffic, an asphalt or cape seal surfacing layer may be placed.
- Geotextile reinforced sprayed seal on unbound granular base and cemented subbase - typically used for pavement widenings on heavily trafficked rural roads. The geotextile seal is provided to inhibit reflection cracking from the cemented material and may also be placed on full depth granular configurations to improve seal performance.
- Full depth asphalt pavement may be used for widenings and strategically important road projects.

Urban roads

- Asphalt surfaced unbound granular pavement - including at least two asphalt layers with a minimum total asphalt thickness of 75 mm. Two asphalt layers have proven necessary to provide a structure with acceptable risk of premature distress and reduce the likelihood of potholes. For heavily trafficked roads the asphalt thickness that ensures adequate fatigue life usually exceeds 200 mm.
- Asphalt surfaced cemented subbase pavement - often referred to as asphalt cemented composite pavement, comprising thick asphalt on two cemented subbase layers placed on the same day. For heavily trafficked roads, a minimum asphalt thickness of 175 mm is used to inhibit reflection cracking. For moderately traffic roads lower asphalt thicknesses (refer *Figure 3.1*) may be used to reduce initial construction costs, but increased performance risks and higher maintenance costs need to be considered in the whole-of-life costing. The design life usually excludes the post cracking phase (refer 8.2.4).
- Minimum 175 mm thickness of asphalt on a single 150 - 200 mm cemented subbase and in some States referred to as a deep strength asphalt pavement. When the design traffic exceeds 10^7 ESA, the asphalt thickness is determined without allowing for a cemented post-cracking phase.

Some heavily trafficked roads (e.g. freeways) have high level performance requirements and need to be designed to minimise traffic delays due to road maintenance during their service lives. Such pavements commonly have a design traffic loading exceeding 10^7 ESA and are referred to as “heavy-duty” pavements in this Supplement.

The following pavement types are considered to be heavy-duty pavements:

- thick asphalt (>175 mm) on 150 - 200 cemented subbase, no post-cracking
- full depth asphalt
- jointed plain (unreinforced) concrete pavements (PCP)
- jointed reinforced concrete pavements (JRCP)
- continuously reinforced concrete pavements (CRCP)

The factors affecting the selection of heavy-duty pavement type include:

- differential settlement;
- scale of works;
- construction works under traffic;
- required surfacings type, including consideration of noise, spray etc;
- maintenance requirements; and
- economics, including whole-of-life costing.

To increase the founding strength and uniformity of pavement support, heavy-duty pavements include granular working platforms, Type A or Type B selected filling (Classification A or B of the DPTI Master Specification for Roadworks Part 210), or insitu stabilisation of subgrades. The minimum thickness requirements for heavy duty pavement supporting layers are shown in *Table 2.4*.

The heavy-duty flexible pavement types most likely to be constructed by DPTI are indicated in *Table 2.5*. To date, very few rigid pavements have been constructed on the South Australian road network.

Table 2.4 Minimum support requirements for heavy-duty pavements

Subgrade Design CBR (%)	Support Treatment Options and Material Quality Requirements* (CBR)	Minimum Thickness (mm) [#]
> 10	PM2 or Characteristic Strength[†] ≥ 30	150
3 – 10	Insitu Lime Stabilisation[‡]	250
	150mm PM2 or Characteristic Strength[†] ≥ 30 over 150mm Type A or B and Characteristic Strength[†] ≥ 15	300
< 3	150mm PM2 or Characteristic Strength[†] ≥ 30 over 250mm Insitu Lime Stabilisation[‡]	400
	150mm PM2 or Characteristic Strength[†] ≥ 30 over 350mm Type A or B and Characteristic Strength[†] ≥ 15	500

* Shall comply with Part 210 and Part 215 DPTI Master Specification for Roadworks

† Characteristic Strength defined in Section 5.9 (i.e. equal to 10th percentile of 4 day soaked CBR)

‡ Laboratory investigation of binder content to ensure long term Characteristic Strength ≥ 30

Geofabric or geogrids and subsoil drainage may also be needed for weak or wet subgrades. Reactive soils require a minimum pavement support thickness of 600mm and/or other appropriate moisture control measures.

Table 2.5 Typical Heavy-Duty Flexible Pavements

Pavement	Full depth asphalt	Asphalt on single layer cemented material
Depth below road surface (mm): 100, 200	200 mm (min) asphalt (excludes Open Graded AC)	175 mm (min) asphalt (excludes Open Graded AC) use SAMI* when asphalt < 200mm
300	150 mm PM2 granular working platform or insitu stabilisation as per Table 2.4	150 – 200 mm plant mixed cemented subbase materials
400, 500	Type A or B fill or insitu stabilisation as per Table 2.4	150 mm PM2 granular working platform or insitu stabilisation as per Table 2.4
600, 700	Subgrade	Type A or B fill or insitu stabilisation as per Table 2.4
		Subgrade
Notes	• Asphalt thickness variable, usually 250 - 350 mm	• Asphalt thickness variable, usually > 200 mm on 150 – 200 mm cemented subbase • * Strain Alleviating Membrane Interlayer

The selection of pavement type requires some knowledge and experience of the local configuration details and materials that have previously proven successful. The design, construction and performance of pavement configuration types that are first time applications to a locality are likely to involve additional risk factors that require careful consideration.

The Supplement and the Guide do not contain provisions for settlement below the pavement layers. Where required, additional investigations and assessments shall be carried out to determine if settlement may occur and, if so how this affects the choice of pavement type.

The design procedures in the Guide have been developed over many years using mechanistic modelling and in-service field performance data. These pavements were generally designed and constructed to outlast 20 years or more of trafficking, with the loading spread more or less evenly over the design period. However, in some situations (e.g. temporary pavements) the pattern of loading differs markedly from that on which the procedures in the Guide were based. Section 7.4.4 provides direction on how the design traffic is calculated for such situations.

2.3 Overview of Pavement Design Systems

2.3.1 Input variables

Design traffic

This Supplement refers to pavements within three South Australian traffic loading categories, comprising lightly, moderately and heavily trafficked roads. The following guidance is given on the load intensities of these categories:

- lightly trafficked roads have design traffic loadings less than 1×10^5 ESA;
- moderately trafficked roads have design traffic loadings greater than or equal to 1×10^5 ESA and less than 5×10^6 ESA; and
- heavily trafficked roads have design traffic loadings greater than or equal to 5×10^6 ESA.

Project reliability

Minimum project reliability levels to be used on DPTI roads are shown in *Table 2.3*.

Table 2.3 Minimum project reliability levels

Road class	Project reliability (%)
Freeways	95
Highways and Main Roads	95
Other Roads	90

3 CONSTRUCTION AND MAINTENANCE CONSIDERATIONS

3.1 General

The design procedures in this Supplement assume that appropriate DPTI standards of construction and maintenance practices are used. These standards are generally defined by the DPTI Master Specification for Roadworks (http://www.dpti.sa.gov.au/) with additional information also available from various Austroads publications, DPTI internal reports, and the proceedings of technical conferences.

Unless appropriate construction standards are met, modulus, thickness or other critical properties assumed in the design model may not be achieved and adverse pavement performance could be expected.

3.2 Extent and Type of Drainage

Due to the relatively low rainfall and high evaporation rates in South Australia, sub-surface drains are generally not provided for pavements except in areas where definite water seepage is identified. These situations include hillside cuttings and areas where the median or verge irrigation may lead to water ingressing the pavement.

Ground water site investigations should preferably be undertaken during the wetter months as these flows may be seasonal. Where the site investigation occurs outside the wettest period and seepage observations are inconclusive, sub-surface drains may need to be installed in some high risk areas as a precautionary measure.

3.6 Use of Stabilisation

Where cemented material layers are placed close to the surface of the pavement, reflection of shrinkage cracking must be expected. In such situations, crack sealing and maintenance patching may be required. Crack sealing in dense graded asphalt surfacings is often more effective than crack sealing of sprayed seals.

The thickness of asphalt or granular material required above a cemented material layer to inhibit reflection cracking will depend on a number of factors, which include traffic loading, environment, quantity and type of binder used, curing practices, parent material properties, construction conditions and degree of subgrade support.

The minimum required cover of dense graded asphalt to inhibit reflection cracking is illustrated in *Figure 3.1*. The reduction in cover with lower traffic loading is in part related to the higher tolerable amounts of surface cracking for lower traffic volume roads. If a thickness less than 175 mm is used, higher crack sealing and patching maintenance costs need to be considered in the whole-of-life costing. DPTI field performance studies conclude that the use of a SAMI reduces the severity of reflective cracking and should be placed where the asphalt cover is less than 200mm.

Granular materials may be used as cover either solely or in conjunction with asphalt subject to the following criterion:

Equivalent thickness of dense graded asphalt = (0.75 × thickness of granular material cover) + (thickness of asphalt cover)

Figure 3.2 illustrates the combinations of asphalt and granular thicknesses that inhibit reflection cracking and are considered equivalent to 175 mm dense graded asphalt.

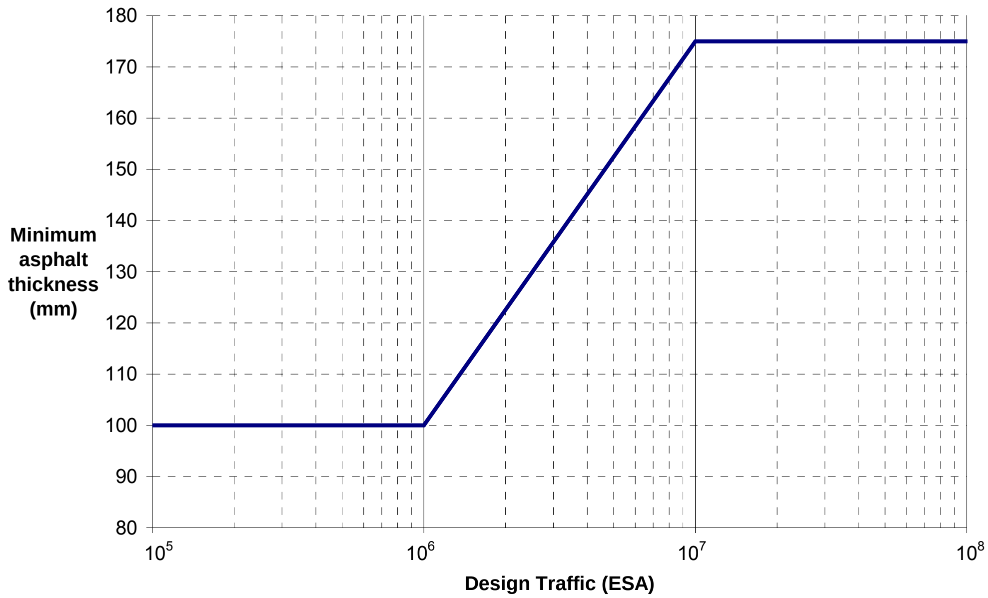

Figure 3.1 Minimum cover to inhibit reflection cracking

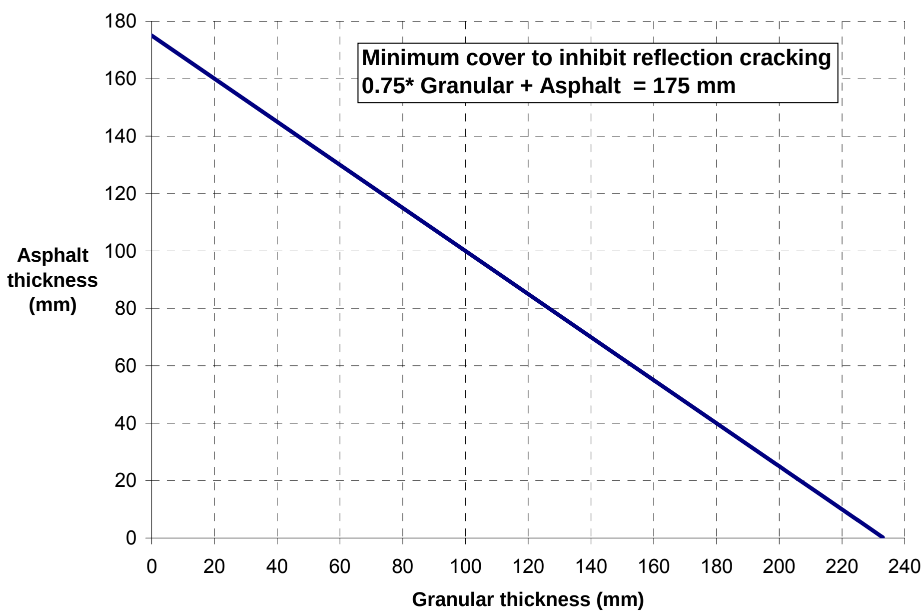

Figure 3.2 Asphalt and granular thicknesses to inhibit reflection cracking.

3.6.1 Single layer plant mixed cemented materials

The achievement of the specified compaction of cemented materials is essential for the development of the modulus and fatigue characteristics assumed in the design. The lower part of the cemented course is particularly critical as this is the zone in which maximum tensile strains occur. This requirement for adequate compaction limits the maximum layer thickness in these materials. For the construction of new pavements, the maximum single layer cemented thickness is 200 mm. The ability to obtain the required field density within the operating constraints of the construction equipment in urban areas (e.g. vibration) may reduce this maximum thickness for some projects.

Cemented materials may incur fatigue damage due to construction traffic unless they are sufficiently thick and adequately supported by the underlying materials. The minimum thicknesses of cemented material necessary to avoid fatigue damage during construction are given in *Figure 3.3* and depend on the strength of the underlying material at the time of construction. For thicknesses less than those given in *Figure 3.3*, the fatigue damage during construction needs to be considered in assessing the fatigue life of the cemented material.

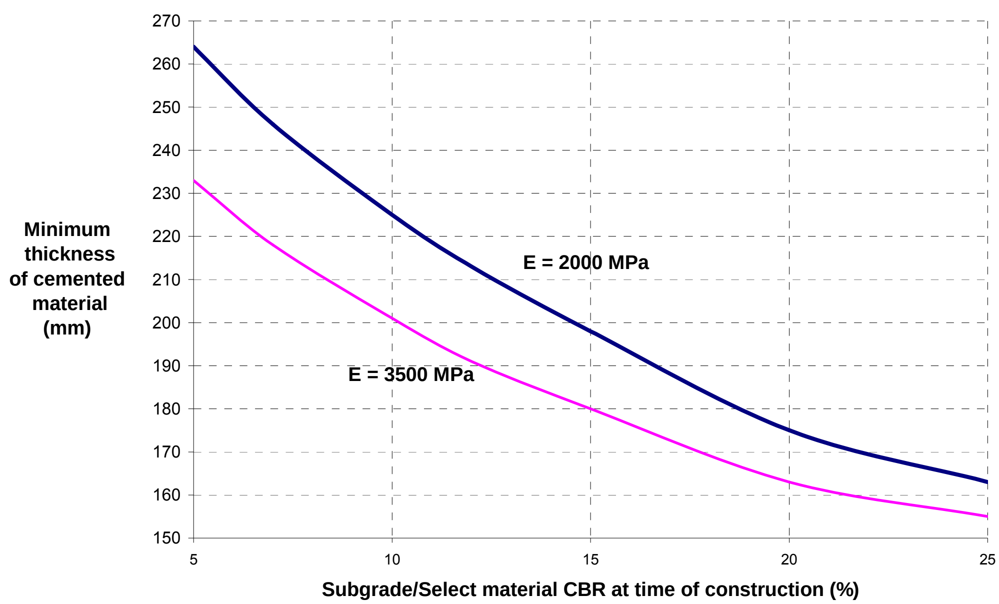

Figure 3.3 Minimum thicknesses of cemented materials to avoid fatigue damage during construction

3.6.2 Multi-layer plant mixed cemented materials

When the cemented material thickness of new pavements exceeds the maximum single layer thickness, multi-layer construction is necessary. For these pavements, the minimum and maximum thickness of each layer is 125 mm and 175 mm respectively. Hence the total thickness of cemented material for two-layer construction can vary between 250 and 350 mm. No more than two layers are considered fully bonded together in the mechanistic design calculation (refer Section 8.2).

In the construction of multi-layered cemented materials, layers designed to be fully bonded need to perform structurally as a single layer, otherwise they should be modelled as two unbonded layers. The effect on fatigue life of inadequate bonding between cemented material layers can be evaluated using mechanistic modelling. *Figure 3.4* illustrates an example where the cemented material fatigue life decreases by a factor in excess of 100 when the interface between two layers is smooth rather than rough.

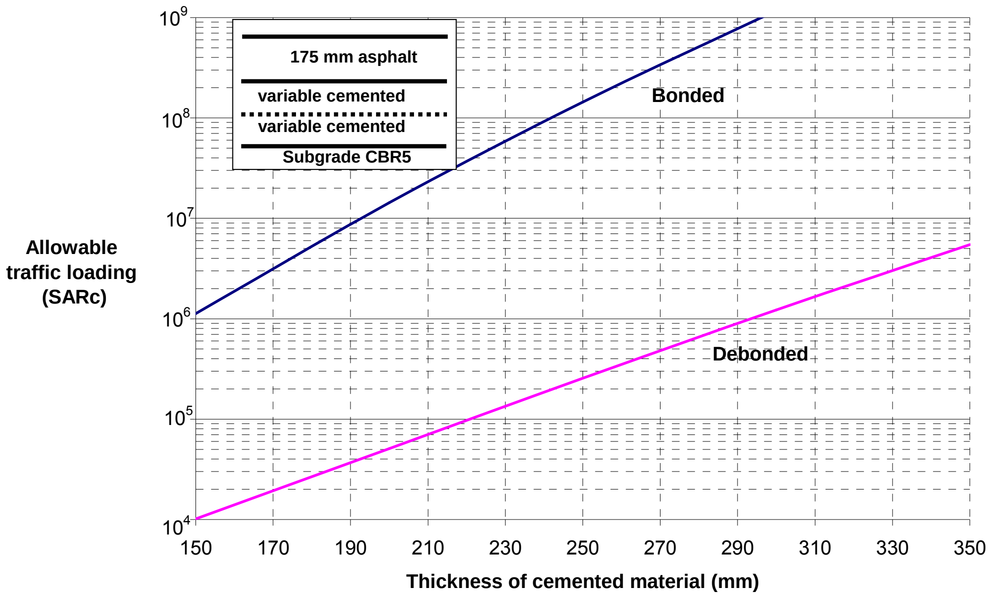

Figure 3.4 Effect of lack of bonding between cemented material layers

Shrinkage cracks which propagate to the pavement surface provide pathways for the infiltration of moisture, which can lead to debonding at layer interfaces within the pavement and/or weakening of the underlying granular layers and subgrade. Hence same day placement of multiple layers is essential, not only to achieve effective chemical bonding between the layers, but also to ensure shrinkage cracking is continuous through the multiple layers. If this does not occur and shrinkage cracking terminates at the interface between layers, surface moisture entering the pavement and accumulating at the interface is likely to initiate debonding and be exacerbated by the pumping effect of dynamic wheel loadings. The delay between commencing placement of each successive layer should not exceed 6 hours.

The moisture ingress to the subgrade through shrinkage cracks extending full pavement depth also requires consideration. It is difficult to accurately quantify this effect on subgrade strength and it will vary from site to site. In general the adopted subgrade design CBR values should not exceed the soaked CBR test results.

Note that the long-term performance characteristics of multi-layer cemented material construction have yet to be fully established in South Australia. Many lane kilometres of moderately to heavily trafficked pavements have been constructed from 1989 onwards. Generally these pavements consist of about 140 – 150 mm asphalt over two layers of cemented materials placed on the same day. With the exception of varying degrees of shrinkage or environmental cracking, these pavements tend to be indicating satisfactory structural performance.

In selecting this type of construction, designers need to be aware that the risk of premature distress increases as the design traffic loading increases.

3.7 Pavement Layering Considerations

The number and thickness of asphalt layers should be determined based on DPTI specification limits, construction practicalities and performance requirements.

The following pavement layer thickness constraints and preferences apply:

a) All layer thicknesses shall conform to DPTI specifications and requirements of *Table 3.1*.

b) A minimum total thickness of 75 mm of asphalt placed in two layers is required over unbound granular material, except for rural intersections where single asphalt layers may be used over sprayed seals to withstand localised high horizontal shear stresses.

c) A minimum total thickness equivalent to 100 – 175 mm asphalt is required over cemented subbase (refer Section 3.6).

d) A minimum 35 mm thickness of asphalt wearing course shall be provided.

e) DPTI Master Specification for Roadworks Part 227 includes Type AC14HB, which has lower air voids and additional binder to provide improved fatigue resistance. To inhibit rutting of these mixes, a minimum thickness of cover of 125 mm of dense-graded asphalt is required.

f) At least three asphalt layers should be used where the total asphalt thickness exceeds 120mm, and preferably four layers when greater than 220mm, to provide better riding surfaces.

g) High bitumen content asphalt fatigue layers at the bottom of full depth asphalt pavements should be between 50 – 60 mm thickness.

h) Consecutive asphalt layers should generally differ by not more than one mix size.

Table 3.1 Pavement layer thicknesses

Material	Mix Size (mm)	Layer Thickness# Range (mm)	Typical As Constructed Thickness (mm)
Asphalt	7	20-35	25
	10	25-50	35 or 40
	14	35-75	50 to 65
	20	50-100	75 to 90
	28	70-150	-
Unbound granular	20	80 - 175	150
	30	90 - 175	150
	40	100 - 200	175
	55	130 -220	175
Plant mixed cement stabilised – single layer construction	All sizes	125 – 200*	150 - 200
Plant mixed cement stabilised – multiple layer construction	All sizes	125 – 175*	150

* Consider also minimum thickness necessary to inhibit damage during construction as discussed in Section 3.6.1

\# Construction tolerances need to be considered and minimum layer thicknesses are generally not acceptable

3.8 Use of Strain Alleviating Membrane Interlayers

To inhibit reflection cracking, a strain alleviating membrane interlayer (SAMI), generally size 10 mm S25E 1.8 – 2.0 l/m^2, shall be applied on top of cemented material subbase layers when the dense mix asphalt cover is less than 200mm. The thickness of a SAMI shall not be included in the design pavement thickness.

3.14 Improved Subgrades

3.14.1 Soft subgrades

Lime stabilisation of soft subgrades or excavation and replacement are treatments that are commonly used as construction expedients in DPTI works. Adoption of an improved design subgrade modulus due to these treatments should only occur if the long-term properties have been validated by thorough field and laboratory testing. These treatments are mechanistically modelled in the same manner as selected subgrade material.

3.15 Surfacing Type

Tables 3.2 and *3.3* provide guidance for the selection of sprayed seal and asphalt surfacing types.

A sprayed seal or SAMI should be provided as a waterproofing layer below a Stone Mastic Asphalt (SMA) or Open Graded Asphalt (OGA) wearing course.

Table 3.2 Guide to the Selection of Sprayed Bituminous Surfacings as an Initial Treatment

Period when Treatment Applied	Open to Traffic Immediately	Initial Trafficking between April to September
October to March*	Prime† pavement with very light prime (AMC 00) or medium prime (AMC 0) followed in not less than three days by 14/7 or 16/7 double seal	Apply prime† and 7 or 10 mm seal followed the next summer by 14/7 or 16/7 double seal after several weeks of summer trafficking has occurred.
April	Very light prime followed by 14/7 or a 16/7 seal. Where a geotextile is required‡ adopt a 7 mm or 10 mm initial seal. Ensure this seal receives warm weather trafficking for 2 weeks, and then apply 14/7 or 16/7 geotextile double seal.	
May to September	7 mm or 10 mm primerseal#. Traffic in warm weather for 2 weeks (emulsion) or 3 months (cutback) prior to applying final seal in summer. Preferably postpone surfacing treatment until October and apply prime and double seal.	

* In areas north of Port Augusta, October to April may be appropriate

† Selection of prime type depends on type of basecourse material and porosity of surface. Embedment allowances over primed basecourse are determined in accordance with Austroads 2000 Seal design method. Maximum permissible ball penetration values will depend on traffic volume and composition.

‡ Application of geotextile seals should be limited to the period between November to March inclusive.

It is advisable to leave cutback primerseals exposed for 6 – 12 months. Emulsion primerseals may have a final seal applied after several weeks of trafficking in hot weather.

Notes:

1. The presence of salt in the basecourse can result in damage to new seals. Where salinity may be an issue, specialist advice should be sought.
2. Normally C170 bitumen used for new construction. In marginal weather conditions polybutadiene (PBD) based binder should be used in the bottom coat of double seals.

Table 3.3 Guide to the Selection of Asphalt Types

Course		General Mix Designation	Binder Class	Target Mix Design Air Voids (%)	Applications/Comments
Wearing	Heavy Duty Wearing Course	AC10H	A35P	4.5	Heavy Vehicle route, significant grades, approaches to heavily trafficked signalised Intersections (0-150m), Roundabouts, Bus Lanes, Bus Stops.
	Medium Duty Wearing Course	AC10M	A15E*	4.5	Other signalised and non signalised Intersections, mid block zones.
		OG14	A15E	20	Non signalised Intersections, mid block zones, no high horizontal shear locations.
		SMA10	A15E*	3.5	
Structural	Modified Intermediate Course	AC10M, AC14M, AC14H	A35P	4.5	Heavy Vehicle route, significant grades, approaches to heavily trafficked signalised Intersections, Roundabouts, Bus Lanes, Bus Stops. AC10M required where wearing course delayed. AC14H for special heavy duty applications.
	Standard Intermediate Course	AC10M, AC14M, AC14H	C320	4.5	Other Intersections, mid block zones. AC10M required where wearing course delayed. AC14H for special heavy duty applications.
	Base	AC14M	C320	4.5	Normal Works.
		AC20M	C320	4.5	Rarely used, mainly for rehabilitation treatments.
		AC14HB	C320	3.0	High binder fatigue resistant layer for full depth asphalt configurations
Special Surfacings	Medium Duty Thin Flexible	SMA7	A15E*	3.5	Texture, Noise Reduction, no high horizontal shear locations.
		OG10	A15E	20	Texture, Noise & Spray Reduction, no high horizontal shear locations
	Footpaths, Bikeways, Crossovers and Carparks	FineAC7L	C170†	4.0	Light maintenance vehicles, minimal heavy vehicles.
		FineAC10L	C170†	4.0	Medium to heavy maintenance vehicles, minimal heavy vehicles.

* A35P may also be approved, and is more common for rehabilitation treatments.
† C320 may also be approved.

Note: DPTI asphalt mix size designations are based on ensuring there is 10% of this nominal size material within the mix. (e.g. AC10 has a minimum 10% material retained on 9.5 mm sieve and AC20 has minimum 10% retained on 19mm sieve etc.) These may be coarser than other typical interstate mixes.

Asphalt surfacings in high speed or other special situations requiring good texture depth for skid resistance, should comprise SMA or OGA.

Dense graded asphalt or SMA wearing courses on bridge decks and concrete pavements shall be 50mm thickness over a very light prime and 10mm S25E SAMI (refer 8.3.5(d)), with a maximum combined thickness of 60mm. Where OGA surfacing is required in these situations, it should be placed over a prime, SAMI, and dense graded asphalt layer, with a combined total thickness of 80-90mm. All bridge surfacing treatments exceeding 60mm total thickness require appropriate bridge design calculations and approvals.

3.17 Pavement Jointing Considerations

Longitudinal joints also occur where it is not practicable to construct a pavement layer across the full width of the carriageway in a single operation. The structural competency of the pavement at longitudinal construction joints is generally not as sound as in other areas. As a result, pavements tend to be weaker and more permeable at longitudinal construction joints. Load induced deformation and/or shrinkage cracking of cemented materials can occur along these discontinuities.

To reduce the risk of premature distress, construction joints should not be located in wheel paths.

3.18 Maintenance of Open Graded Asphalt Surfacings

The replacement of open graded asphalt surfacings by cold planing can accelerate stripping of the underlying asphalt. Grooves formed in the underlying dense graded asphalt from the rotor mill process allow small water reservoirs to develop at the interface. In addition, inadequate level control during milling can result in depressions at the interfaces with the pavement which may result in water ponding within the pavement.

If open graded asphalt surfacing is to be used over a milled surface, a correction course of small size dense graded asphalt, such as AC10, must be used to provide an interface which will facilitate the shedding of water which permeates through the open graded asphalt.

3.19 Shoulders

Shoulders provide structural support to the pavement edge. If not designed and constructed using the same adjacent pavement composition, the functional purpose of the shoulder needs to be carefully considered so that appropriate materials and thicknesses are used. This is particularly important where the shoulder is sealed and may be used as a heavy vehicle climbing lane, for parking of vehicles or may be frequently trafficked on the inside edge of curves etc.

For unsealed shoulders, the minimum total thickness of granular materials is 150 mm for major Rural Arterials and 200 mm for National Highways. The uppermost 100 mm or more should be a Class 2 pavement material or similar with reasonably high plasticity index (6 to 8) to provide low permeability and good surface integrity.

Refer to Section 8.3.4 of the Supplement for selection of thickness and materials for shoulders constructed adjacent to granular pavements with thin bituminous surfacings. Section 9.3.5 of the Guide describes how shoulders are considered as an integral part of the base thickness design process for rigid pavements.

3.20 Settlement

The Supplement and the Guide do not contain provisions for settlement below the pavement layers. Where required, additional investigations and assessments should be carried out to determine if settlement may occur and, if so whether pre-treatment (such as drainage and surcharge) of the formation is required to reduce the amount of settlement after the pavement is constructed.

3.21 Frequency of Maintenance Treatments

The whole-of-life costing (Chapter 10) requires the maintenance costs of pavement alternatives to be estimated over the analysis period.

The Austroads *Guide to Pavement Technology Part 3: Pavement Surfacings (2009).* provides guidance on the range of expected service lives of surfacings. There are some situations (e.g. expansive subgrades, subgrades subject to settlement) where higher than normal frequency and extent of maintenance are required to seal the pavement and restore shape.

4 ENVIRONMENT

4.1 General

Australian climatic zones based on temperature and humidity are indicated in *Figure 4.2*[1]. Most of the coastal areas of South Australia experience warm summers and cool winters, while the more scarcely populated regions are generally within the Hot, Dry Summer, Cold Winter zone.

South Australia is relatively dry compared to other Australian states and typically has low rainfall and high evaporation rates as shown in *Figure 4.3*[2] and *Figure 4.4*[3]. Except for the south east corner of South Australia, the remainder is wholly arid or semi-arid. The south east corner, including Adelaide, has dry summers with median annual rainfall of 400 – 800 mm, mostly in the winter months.

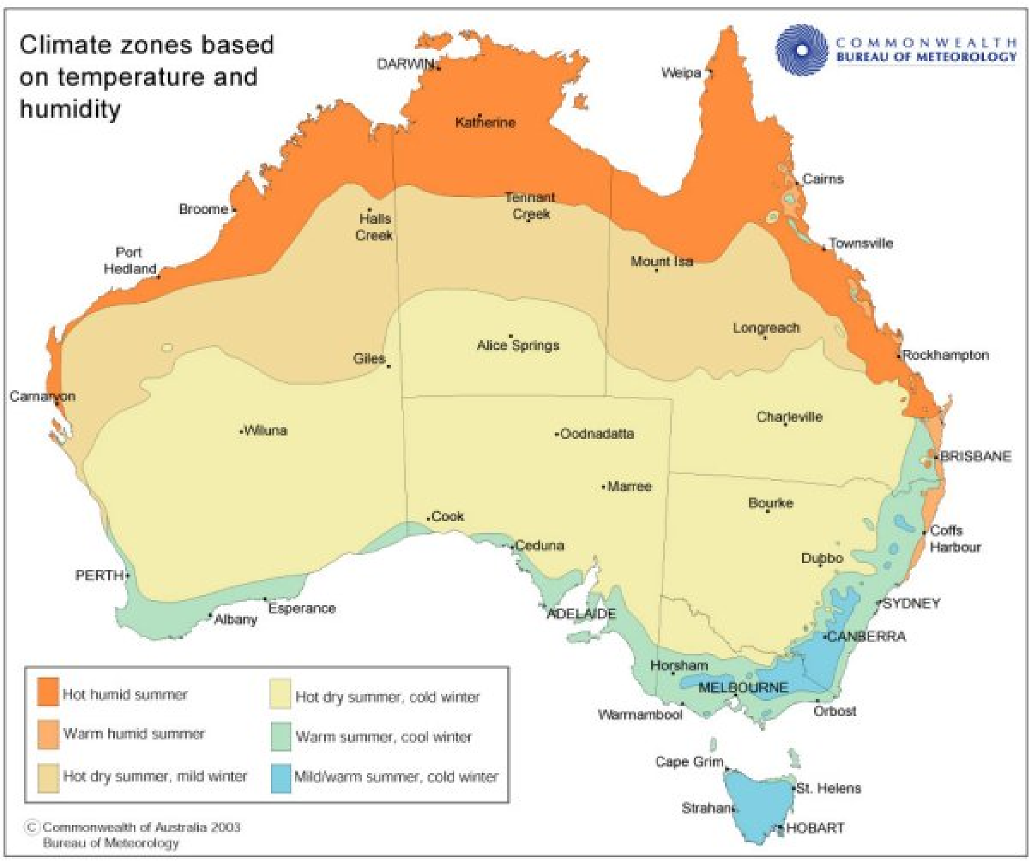

Figure 4.2 Australian climatic zones (www.bom.gov.au/climate/averages)

[1] *Source: Commonwealth Bureau of Meteorology 2003, copyright Commonwealth of Australia reproduced by permission.*

[2] *Source: Commonwealth Bureau of Meteorology 2001, copyright Commonwealth of Australia reproduced by permission.*

[3] *Source: Commonwealth Bureau of Meteorology 2003, copyright Commonwealth of Australia reproduced by permission.*

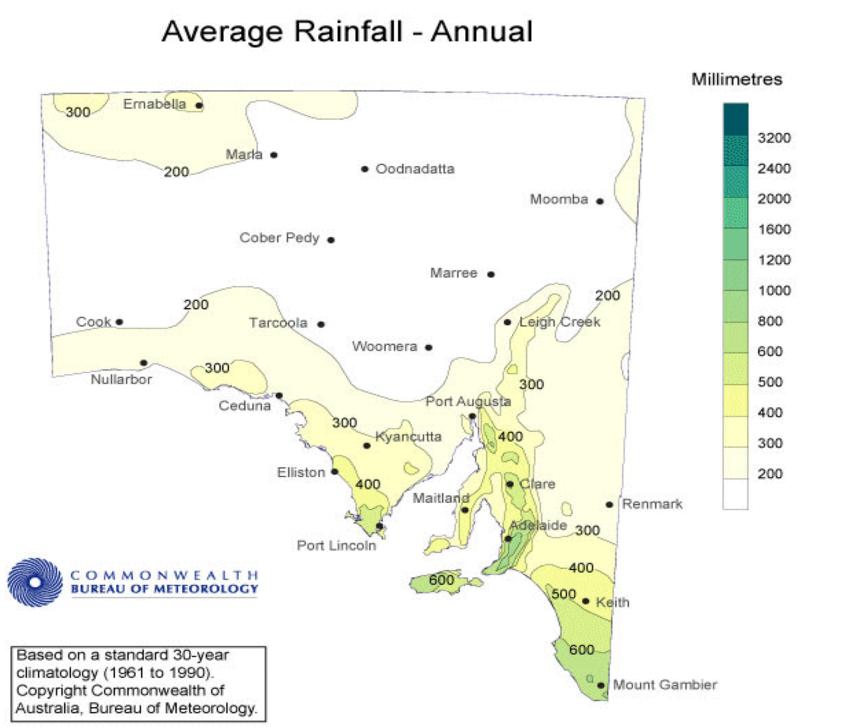

Figure 4.3 Average annual rainfalls for South Australia (www.bom.gov.au/climate/averages)

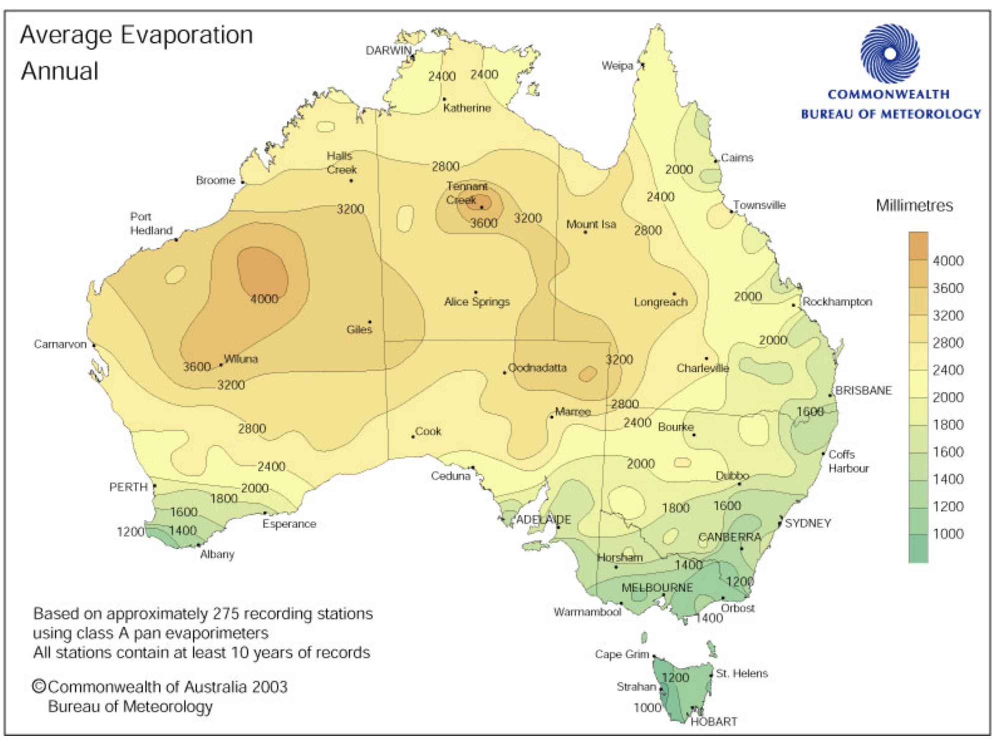

Figure 4.4 Average evaporation map - Annual (www.bom.gov.au/climate/averages)

5 SUBGRADE EVALUATION

5.3 Factors to be Considered in Estimating Subgrade Support

5.3.5 Moisture changes during service life

5.3.5.1 Expansive soils

Soils change in volume as their moisture content changes. The magnitude of the volume change depends on:

- the potential swell/shrinkage of each material under the pavement;
- extent (width and depth) of each material; and
- magnitude of changes in moisture content.

Hence strategies to inhibit loss of shape due to reactive soils include:

- minimising the changes in moisture content from the time of construction; and
- removing the reactive soil in the zone of seasonal moisture change and replacement with a non-reactive material.

The Guide lists a number of construction approaches.

In wetter areas of Australia where reactive soils expand in volume after construction, some road agencies place a non-reactive fill to surcharge the reactive soil to minimise the expansion. This may not always be appropriate for South Australia as often the reactive soils reduce in volume rather than expand.

In the event that expansive soils have been identified for a project, a geotechnical assessment is required to assess the risks of future pavement shape loss and the most appropriate treatment strategy.

Moisture changes in reactive soils may be reduced by covering with a low permeability select fill layer with maximum Weighted Plasticity Index (WPI) of 1200.

DPTI also generally adopts a minimal disturbance approach to preparing subgrades to take advantage of the usually higher undisturbed soil strengths and to retain any relatively dry equilibrium conditions that may be encountered. Reworking these subgrades or exposing them during wet periods can lead to building in undesirable moisture contents that are above equilibrium, with the risk of shrinkage deformation and cracking of the pavement surfacing.

5.6 Laboratory Determination of Subgrade CBR and Elastic Parameters

Laboratory preparation and testing conditions normally adopted by DPTI to determine the subgrade design CBR are as follows:

- Density Ratio of 98% using Standard compactive effort and optimum moisture content; and
- 4.5 kg surcharge and 4-day soaking.

It is recommended that prior to the 4-day soaking, specimens also be tested unsoaked to assess their sensitivity to moisture variations that may occur during construction and in service.

The vertical design modulus of a subgrade is determined from its design CBR and *Equation 2* of the Guide. A maximum vertical modulus of 100 MPa shall apply to normal soil subgrades and where sound rock formations exist, a maximum value of 150 MPa is applicable.

If insitu stabilisation of the subgrade is undertaken after detailed field and laboratory investigations have verified the long-term performance properties (Little, 1995), these stabilised layers are characterised as selected subgrade materials (refer Section 5.9).

5.7 Adoption of Presumptive CBR Values

The presumptive subgrade CBR value for each material type shall not exceed the lowest of the range of values given in *Table 5.4* of the Guide.

5.9 Selected Subgrade Materials

Select fill or selected subgrade materials may be provided above the insitu subgrade to:

- provide a working platform on which to compact pavement layers, particularly over soft subgrades;
- increase the strength and uniformity of the supporting pavement substrate;
- increase the height of pavements on embankments; and
- reduce moisture changes of highly expansive subgrades (refer Section 5.3.5.1).

In some situations (refer Section 3.14) it may be necessary to excavate soft or expansive subgrades prior to placement of the fill.

Fill materials shall meet the requirements of Classification A or B of DPTI Master Specification for Roadworks Part 210 and the following:

a. The Characteristic Strength of a fill material is defined as the tenth percentile value (i.e. mean – 1.3 x standard deviation) of the laboratory 4-day soaked CBR results from at least six samples. The samples shall be taken in accordance with the test procedure TSA-MAT-TP226 with at least one sample from each of six Lots. The design CBR of any particular fill material shall not be greater than two-thirds of the Characteristic Strength.
b. The top 150 mm of fill shall have a minimum Characteristic Strength of CBR 15% and a maximum vertical design modulus of 100 MPa.
c. Fill materials with a WPI greater than 1200 shall not be used directly below pavements.
d. Swell values determined with 4.5kg surcharge and 98% Standard compaction should be < 1% wherever possible.

Lime stabilisation of clay subgrades (3% - 5% hydrated lime) has proven a successful and cost effective construction expedient for DPTI on a number of projects. Where minimal or no field and laboratory testing is undertaken for these applications, such treatments are not considered in the pavement design calculations.

However, if appropriate site investigations and laboratory testing for lime demand and Unconfined Compressive Strength (UCS) are used to verify the long-term properties of the lime stabilised subgrade (Little, 1995), the structural contribution of the layer may be considered in the same manner as a selected subgrade material. The Characteristic Strength is determined and the design CBR calculated as two thirds of this value, with an upper limit of CBR 15. The design vertical modulus of the top sublayer (refer Section 8.2.2) is 10 times the design CBR of the lime stabilised material up to a maximum value of 150 MPa.

6 PAVEMENT MATERIALS

6.1 General

The Guide and the Supplement provide procedures for pavement design using materials that comply with DPTI Master Specification for Roadworks Part 215. For non-standard materials, similar performance relationships and presumptive modulus values may not be applicable.

6.2 Unbound Granular Materials

6.2.1 Introduction

Availability of materials

A simplified surface rock map of South Australia is illustrated in *Figure 6.13*. It is apparent that hard rock sources are very limited in extent. Igneous rocks occur in some small outcrops in the central and far north-west of the state. Basalt is quarried near Mt Gambier. Metamorphic hard rocks are to be found on the Eyre Peninsula and in the Mt Lofty/Flinders Ranges. Otherwise sedimentary and superficial surface materials cover the state. Calcretes, with or without processing, are extensively used and perform satisfactorily on light to moderately trafficked roads. In outback areas a wide range of local materials are utilised including high gypsum content rubbles, shales, tableland stone, iron pan, river gravel and clays.

Further details on material availability can be found in Robinson, Oppy and Giummarra (1999).

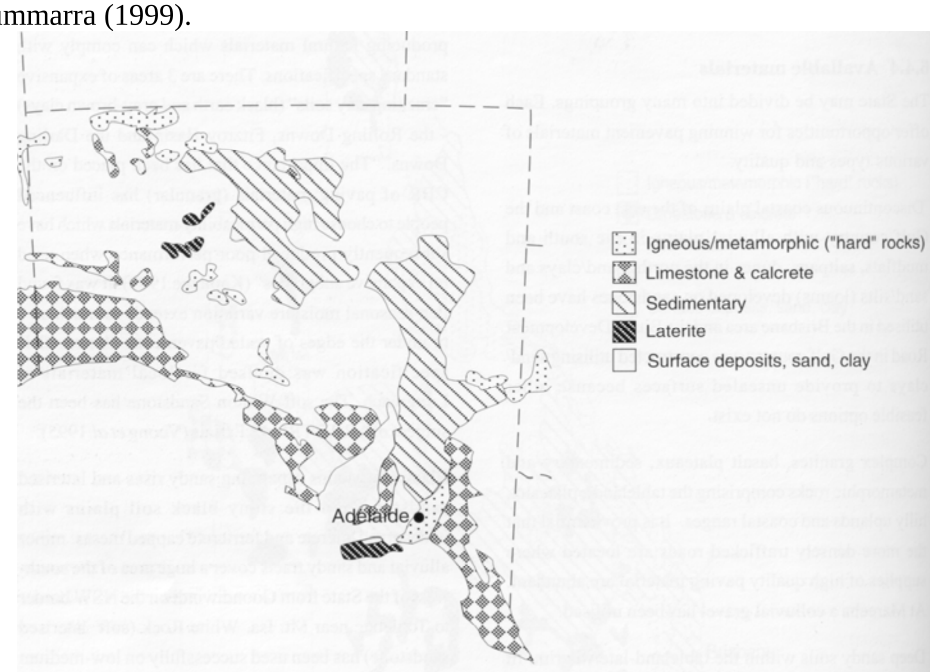

Figure 6.13 Simplified surface rocks map of SA (Robinson, Oppy and Giummarra, 1999)

Standard granular materials

The quality and strength characteristics required of granular materials depends upon the following factors and their interactions:

- traffic (volume, axle group types and loads)
- climate
- pavement configuration and drainage
- subgrade

Lightly traffic roads in dry environments can more successfully use lower quality granular materials than roads with higher traffic loadings in wet environments.

DPTI Master Specification for Roadworks Part 215 details requirements for standard granular materials comprising crushed quarry products, natural gravel, sand and recycled pavement materials. These specifications include the range of products that meet traditional grading based manufacturing tolerances, as well as those that use performance based mix design limits to deliver the required stiffness, shear strength and deformation resistance properties.

Specifications for higher standard Quarried Pavement Materials have recently been developed for the construction of very heavily trafficked unbound granular pavements with thin surfacings, and are designated PM1A or PM1B heavy duty materials. They provide improved stability and workability and are compacted to 100% Modified Maximum Dry Density and dried back to no greater than 60% Optimum Moisture Content, and are placed in layers not exceeding 125mm thickness. However, as their availability is limited, project specific assessment is required.

The general DPTI pavement material types are summarised in *Table 6.16*. Size 40 mm materials are unsuitable as base layers as they tend to segregate during placement and do not provide adequate surface tightness and finish.

Table 6.16 Standard Granular Material Types

Material Type/Class	Source	Size (mm)	Primary Usage
PM1A*, PM1B*, or PM1† (Class 1)	Quarried	20	Base
		30	
PM1† (Class 1)	Recycled	20	
		30	
PM2† (Class 2)	Quarried	20	Upper subbase, lower subbase, working platforms for heavily and moderately trafficked roads, base for lightly trafficked roads
		30	
		40	
	Recycled	20	
		30	
		40	
PM3† (Class 3)	Quarried	20	Working platforms for moderately trafficked roads and lower subbase layers for lightly trafficked roads
		40	
		55	
		75	
	Recycled	20	
		40	

* heavy duty pavement materials use only a grading based specification
† grading based or mix design specifications

Note: Recycled, heavy duty and mix design products require project-specific consideration and DPTI approval.

Non-standard granular materials

Marginal or non-standard granular materials should only be used after consideration of:

- the documented performance history of the proposed material
- costs relative to standard materials
- the predicted traffic loading
- the climate at the site
- the moisture sensitivity of the subgrade
- the quality and uniformity of the materials as shown by laboratory testing
- consequences of poor performance
- suitability and cost-effectiveness of mechanical or chemical stabilisation

These materials commonly have lower moduli than standard granular materials, so greater thickness is required to reduce the stresses/strains on the subgrade. However, it is not always possible to obtain equivalent performance by using thicker layers of non-standard materials.

Thicker pavement layers for lower moduli materials may result in the same subgrade strain as for thinner layers of standard materials; thus the extent of rutting of the subgrade is similar. However, the use of the non-standard materials may result in inferior performance due to deformation within the pavement layers under traffic loading leading to rutting and early pavement distress. The use of repeated load triaxial testing to provide the values for modulus and permanent deformation will assist in predicting the performance of non-standard materials compared to standard materials. Specialist advice should be sought in undertaking such evaluations.

6.2.3 Determination of modulus of unbound granular materials

6.2.3.2 Determination of modulus of top granular layer

Direct measurement

The modulus of granular materials can be determined using repeated load triaxial equipment. As the modulus depends on density, moisture content and stress state, it is essential that the material be tested under conditions which approximate those occurring in service.

DPTI adopts the following conditions for testing of granular materials characterisation:

- 80% modified optimum moisture content
- 98% modified maximum dry density
- Stress conditions as defined by Austroads (2007) and documented in test procedure TSA-MAT-TP 183.

The maximum allowable design modulus from direct measurement shall be 350 MPa.

Presumptive values

In determining the top vertical moduli of DPTI Class 1 base materials, the typical values in *Tables 6.3* and *6.4* of the Guide for normal standard crushed rock shall be used.

For base materials that do not conform to the DPTI Master Specification for Roadworks Part 215 but have proven performance in the field, the maximum modulus shall be 300 MPa under thin bituminous surfacings.

6.4 Cemented Materials

6.4.1 Introduction

6.4.1.3 Cemented material types

The DPTI Master Specification for Roadworks Part 215 details various types of plant-mixed stabilised materials produced by the addition of cement, fly ash, lime, bitumen or combinations of binders to granular material. As cemented materials need to include cementitious binding agents in sufficient amounts to produce a bound layer with significant tensile strength, not all Part 215 stabilised materials meet this definition. The Part 215 materials listed in *Table 6.17* are those DPTI consider to be cemented materials. The source material may be natural quarried material or, where approved, recycled materials complying with Part 215. In addition, stabilised material may be specified by either binder content or strength.

Table 6.17 Cemented material types*

Specification type	Binder	Min 28 day UCS	20 mm Class 2† (PM 2/20)	30 mm Class 2† (PM 2/30)	40 mm Class 2† (PM 2/40)
Binder control	Target binder 4% Type GB cement	-	SPM2/20C4	SPM2/30C4	SPM2/40C4
	Target binder 5% Type GB cement	-	SPM2/20C5	SPM2/30C5	SPM2/40C5
Strength control	Cement, fly ash and/or lime	4MPa	SPM2/20C4MPa	SPM2/30C4MPa	SPM2/40C4MPa
		5MPa	SPM2/20C5MPa	SPM2/30C5MPa	SPM2/40C5MPa

* Materials with a 28 day UCS less than 4 MPa (AS 1141.51) are not used in cemented designs because of durability concerns.
† Class 1 materials may be substituted for Class 2

Finely graded gravels, clayey gravels, silty sands (>50% passing 0.425 mm sieve) and other materials which do not achieve significant particle interlock are not included in the definition of cemented materials as their fatigue performance would be variable and unpredictable.

6.4.3 Determination of design modulus

6.4.3.4 Modulus correlations

The design moduli of cemented materials complying with the DPTI Master Specification for Roadworks Part 215 is described in Section 6.4.3.5.

For cemented materials not complying with Part 215 but which have proven field performance, the design moduli may be determined from UCS test results as follows:

$$E_{FLEX} = 1000UCS \quad (6.11)$$

where E_{FLEX} = flexural modulus (MPa) of field beams at 28 days moist curing, and
UCS = Unconfined Compressive Strength (MPa) of laboratory specimens at 28 days.

The maximum design modulus for these non-standard materials shall not exceed 3500 MPa.

6.4.3.5 Presumptive values

The moduli of cemented material are dependent on a number of factors, including:

- source material quality, grading etc
- binder type and quantity
- compaction and moisture
- curing regime

The design modulus for the cemented materials detailed in *Table 6.17* shall be no greater than 3500 MPa. Note this maximum modulus assumes seven days initial curing with negligible traffic. Following initial curing, a primerseal may be placed to provide a stable moisture regime to promote longer term curing and to assist with bonding to any subsequently placed asphalt layers.

6.4.4 Factors affecting the fatigue life of cemented materials

6.4.4.4 Cracking

Cracking of cemented materials can occur:

a) where environmentally induced stress exceeds the tensile strength of the bound material, e.g. due to shrinkage.

b) at the end of the fatigue life for a bound pavement layer as a result of applied load applications exceeding the fatigue limit.

Environmentally induced stress can result from circumstances such as:

- volume change in pavement layers from moisture and/or temperature changes;
- curling (temperature differentials) and warping (moisture differentials); and
- substrate movement (settlement and/or volume change).

If cracking reflects to the surface of the pavement, this may lead to:

- detrimental materials such as water and incompressibles entering the pavement and subgrade, causing damage and failure;

- underlying pavement layers abrading or eroding, leading to the formation of depressions; and
- the cracks wearing and widening, leading to further deterioration of pavement functionality and structural integrity.

Surface cracking on heavily trafficked roads is minimised by providing a minimum cover equivalent to 175 mm thickness of dense graded asphalt.

For lightly to moderately trafficked roads the tolerable amount of surfacing cracking is greater than for heavily trafficked roads. In such cases a lower minimum cover may be appropriate, but is required to be at least equivalent to 100 mm of dense graded asphalt.

6.5 Asphalt

6.5.1 Introduction

The requirements for asphalt supply and construction are given in the DPTI Master Specification for Roadworks Parts 227 and 228.

A guide to the selection of asphalt for particular applications is provided in *Table 3.3*. Note that AC28 mixes are not recommended as they are subject to segregation during placement.

6.5.3 Determination of design asphalt modulus and Poisson's ratio

6.5.3.3 Determination of design modulus from measured modulus

The maximum asphalt design moduli obtained from the measured indirect tensile test shall not exceed the values in *Table 6.18* for the given mix type, temperature and design speed.

6.5.3.4 Design modulus from bitumen properties and mix volumetric properties

The maximum asphalt design moduli shall not exceed the values in *Table 6.18* for the given mix type, temperature and design speed.

6.5.3.6 DPTI Asphalt Design Moduli

The asphalt design moduli for DPTI Registered Mixes shall be not less than 480 MPa for open graded, 830 MPa for stone mastic, and 1000 MPa for dense mix asphalt, and be determined from *Table 6.18* and the following methodology.

The moduli provided in *Table 6.18* are for the Weighted Mean Annual Pavement Temperature (WMAPT) of 27°C for Adelaide. For other pavement temperatures, the asphalt design modulus shall be the greater of the minimum indicated above, and that calculated from the values in *Table 6.18* using the following equations (Jameson 2005b):

$$S_{WMAPT} = S_{27^{\circ}C} * e^{(A(WMAPT-27))} \qquad (6.12)$$

$$A = (1 + 0.0307*(V_b - 11))*(0.014\ln(V) - 0.1579) \quad (6.13)$$

where S_{WMAPT} = asphalt modulus at the WMAPT (MPa)
S_{27^oC} = asphalt modulus at 27°C (*Table 6.18*) (MPa)
Vb = volume of binder in mix (%)
V = heavy vehicle design speed (*Table 6.19*)
A = mix type and vehicle speed variable

WMAPT for various South Australian sites are given in Appendix B of the Guide.

Table 6.18 Asphalt Design Moduli at WMAPT of 27°C

Mix Designation	Mix Size (mm)	Binder Class	Effective Binder Volume (%)	Design Modulus MPa at 27°C			
				10km/h	30km/h	50km/h	80km/h
AC10M	10	320	12.4	1220	2120	2630	3190
AC10H	10	320	11.7	1360	2330	2880	3480
AC14M	14	320	11.7	1360	2330	2880	3480
AC14H	14	320	11.0	1520	2570	3160	3800
AC20M	20	320	11.0	1520	2570	3160	3800
AC14HB	14	320	13.1	1330	2330	2910	3540
SMA10	10	320	15.1	830	1490	1880	2320
OG14	14	320	9.9	480	790	960	1150

Note: other DPTI Asphalt Mixes (eg Special Surfacings as shown in Table 3.3) are rarely used in mechanistic design models.

As asphalt moduli vary with heavy vehicle speed, a design speed needs to be determined for each project. In the absence of site-specific heavy vehicle travel speed data, the presumptive design speeds given in *Table 6.19* shall be used.

Table 6.19 Presumptive heavy vehicle design speeds

Project location	Design Speed V (km/h)	
	Flat and up to 5% grade	Over 5% grade
Posted speed limit ≥ 80 km/h	80	50
50 km/h ≤ posted speed limit < 80 km/h	50	30
Posted speed limit < 50 km/h	30	10
Low radius roundabouts, bus stops, etc	10	10

The modulus of an asphalt wearing course incorporating polymer modified binders may be estimated by applying the modulus adjustment factors in *Table 6.12* of the Guide to the values for C320 binder mixes given in *Table 6.18* above. Modulus adjustment factors exceeding unity shall not be adopted unless confirmed by laboratory resilient modulus testing of the project mix. Modulus adjustments shall not be made for polymer modified binders used in asphalt layers other than wearing courses.

6.5.8 Recycled asphalt

DPTI supports increasing the use of Recycled Asphaltic Planings (RAP) within its asphalt mixes. Guidelines for incorporating greater than the 20% RAP allowed in asphalt specifications are currently under development by DPTI. Asphalt mixes with RAP are assumed to have the same design modulus and fatigue relationship as the equivalent mix with virgin materials.

7 DESIGN TRAFFIC

7.4 Procedure for Determining Total Heavy Vehicle Axle Groups

7.4.2 Selection of design period

The design periods given in *Table 7.8* are recommended for DPTI flexible pavements.

Table 7.8 Pavement Design Periods for New Flexible Pavements

Type of Road	Design Period (years)
Freeways	30
Highways and Main Roads	30
Other roads	20

7.4.4 Initial daily heavy vehicles in the design lane

Short-term Heavy Loadings

The Guide design procedures have been developed over many years using mechanistic modelling and in-service field performance data. These pavements were generally designed and constructed to outlast 20 years or more trafficking, with the loading spread relatively evenly over the design period.

However, in some situations the pattern of loading differs markedly for that on which the procedures in the Guide were based. For instance:

- Temporary pavements may be required to carry high daily traffic loadings but because of their limited design life (e.g. 0-2 years) may have a relatively low design traffic loading.
- In some areas of the State the haulage of grain results in large seasonal variations in traffic loadings.
- Some bus ways in Adelaide have high loadings on weekends during the winter football season but very low loadings at other times.

In such situations the design traffic needs to be adjusted to allow for the greater impacts of these special loadings. For roads with intermittent or seasonal loadings, rather than the design traffic being calculated from the annual average daily heavy vehicle volume, the maximum daily heavy vehicle traffic per annum is used.

For temporary pavements with a design period of less than 5 years, the design traffic is calculated using a 20 year design period with zero traffic growth rate using the maximum daily heavy vehicle volume.

7.4.5 Cumulative traffic volumes

In accordance with the predicted doubling of road freight by 2020 (DOTARS 2002), all freeways, highways and major arterials on freight routes shall be designed with a minimum heavy vehicle growth rate of 3.5%.

7.4.6 Estimating axle groups per heavy vehicle

Whenever possible, project specific weigh-in-motion (WIM) data should be used to determine N_{HVAG} values rather than presumptive values.
Appendix D of the Guide provides the N_{HVAG} values from all WIM sites throughout Australia, with the 8 South Australian sites summarised in *Table 7.11* below.

7.5 Estimation of Traffic Load Distribution (TLD)

South Australian WIM data has been filtered to remove axle group loadings that exceed the limits shown in *Table 7.9*. These values were determined from discussions with DPTI transport safety compliance officers and consideration of special heavy vehicle types and movements in SA. The processed WIM data is expected to provide the most reliable traffic load distributions for general pavement design purposes.

Table 7.9: Maximum South Australian WIM Axle Group Loadings

SAST	TAST	SADT	TADT	TRDT	QADT
9t	16t	18t	33t	40t	48t

7.6 Design Traffic for Flexible Pavements

7.6.2 Pavement damage in terms of Standard Axle Repetitions

Whenever possible, project specific weigh-in-motion data should be used to determine relevant heavy vehicle parameters rather than presumptive values.

Appendix D of the Guide provides the heavy vehicle characteristics from weigh-in-motion sites throughout Australia, with the 8 South Australian sites summarised in *Table 7.11*. For road projects where there is no suitable WIM data available, typical SA values are indicated in *Table 7.10* but these must be used with caution.

Table 7.10: Typical Heavy Vehicle Characteristics for DPTI Road Categories*

	Urban Roads		Rural Roads		
	General Access	B double & Road Trains	General Access	General B double	Key B double & Road Trains†
N_{HVAG}	2.5	3.0	2.8	3.0	3.4
ESA/HVAG	1.0	1.2	1.1	1.2	1.3
ESA/HV	2.5	3.6	3.1	3.6	4.4
SAR5/ESA	1.2	1.2	1.2	1.2	1.2
SAR7/ESA	2.0	2.0	2.0	2.0	2.0
SAR12/ESA	12	12	12	12	12

* road categories are based on Heavy Vehicle access, refer http://maps.sa.gov.au/ravnet/index.html

† use Pimba WIM data from *Table 7.11* for Triple Road Train routes.

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Table 7.11 Traffic characteristics of South Australian weigh-in-motion sites*

Road	ID	Location	Direction	Lane	N_{HVAG}	ESA/ HVAG	ESA/ HV	SAR5/ ESA	SAR7/ ESA	SAR12/ ESA
Barrier Highway	OWN	Oodla Wirra	N	OL	3.74	1.54	5.77	1.29	2.38	21.46
Barrier Highway	OWS	Oodla Wirra	S	OL	3.71	1.48	5.50	1.26	2.20	15.87
Dukes Highway	BTE	Bordertown	E	OL	3.41	1.13	3.86	1.17	1.73	6.15
Dukes Highway	BTW	Bordertown	W	OL	3.43	1.31	4.49	1.23	2.05	11.72
Eyre Highway	IKE	Iron Knob	E	OL	3.92	1.37	5.37	1.24	2.11	16.57
Eyre Highway	IKW	Iron Knob	W	OL	3.90	1.30	5.06	1.18	1.79	9.98
South East Highway	MOE	Monarto	E	OL	3.17	1.21	3.85	1.23	2.03	10.60
South East Highway	MOW	Monarto	W	OL	3.14	1.32	4.14	1.20	1.82	7.09
Stuart Highway	PIN	Pimba	N	OL	4.64	1.91	8.87	1.32	2.45	16.35
Stuart Highway	PIS	Pimba	S	OL	4.55	1.05	4.77	1.21	1.92	10.25
Sturt Highway	TEA	Truro	E	OL	3.50	1.29	4.53	1.21	1.89	7.57
Sturt Highway	TEB	Truro	E	IL	3.43	1.33	4.56	1.42	3.20	34.19
Sturt Highway	TRW	Truro	W	OL	3.48	1.25	4.33	1.16	1.63	4.80
Riddoch Highway	NAN	Naracoorte	N	OL	3.10	1.26	3.89	1.19	1.78	6.26
Riddoch Highway	NAS	Naracoorte	S	OL	3.11	0.97	3.01	1.14	1.56	4.47
Port River Expressway	WI1	Wingfield	E	OL	2.96	1.23	3.64	1.23	1.97	9.76
Port River Expressway	WI2	Wingfield	E	IL	3.00	0.95	2.85	1.22	2.01	9.90
Port River Expressway	WI4	Wingfield	W	OL	2.86	1.18	3.38	1.24	2.09	12.26
Port River Expressway	WI3	Wingfield	W	IL	3.14	1.08	3.38	1.20	1.87	8.01

* WIM data for 2011.

8 DESIGN OF NEW FLEXIBLE PAVEMENTS

8.2 Mechanistic Procedure

The calculated layer thicknesses shall be rounded up to the nearest 5 mm. To allow for variations in the constructed layer thicknesses within the construction tolerances, 10 mm shall be added to the pavement layer which governs the overall allowable loading.

It is assumed that sprayed seals, geotextiles and SAMIs are non-structural. Geosynthetics that reinforce pavement layers or have load spreading properties are also excluded from the mechanistic modelling procedures.

Generally the mechanistic modelling is undertaken assuming full bonding between layers, characterised as a "rough" interface in the CIRCLY program. However, when modelling pavements with more than two cemented material layers, only one of the interfaces between cemented material layers shall be modelled as fully bonded, and any other interfaces between cemented layers shall be modelled as a smooth interface.

Similarly, if the construction and maintenance procedures are likely to result in some degree of debonding during the design period, the interfaces between cemented material layers shall be modelled as smooth.

8.2.1 Selection of trial pavement

Refer to discussion in Section 2.2.2.

8.2.2 Procedure for elastic characterisation of selected subgrade materials

The maximum vertical modulus assigned to top sublayers shall not exceed 100 MPa, except:

- for fully investigated and designed lime stabilised subgrades; and
- sound rock formations

which have a maximum modulus of 150 MPa (refer Section 5.9).

8.2.3 Procedure for elastic characterisation of granular materials

Class 1, 2 and 3 pavement materials meeting the requirements of the DPTI Master Specification for Roadworks Part 215 shall be considered as unbound granular materials and characterised in accordance with the Guide.

8.2.4 Consideration of post-cracking phase in cemented materials

For heavy-duty pavements incorporating cemented materials no allowance shall be made for the post-cracking phase of design life. For other road pavements where the design traffic is less than 10^7 ESA, designs may include the post-cracking phase of cemented materials if agreed by the project manager.

8.2.6 Unbound granular pavements with asphalt surfacings

For unbound granular pavements with asphalt surfacings less than 75 mm thick, the base and subbase requirements discussed in Section 8.3.2 below shall apply.

Where the total thickness of asphalt is 75 mm or more, the following minimum requirements apply:

Total asphalt thicknesses 75 to 150 mm

- an unbound granular base is required consisting of a minimum 125 mm of Class 1 Quarried Pavement Material or Class 1 Recycled Pavement Material;
- an upper subbase consisting of a minimum 125 mm thickness of Class 2 Quarried Pavement Material or Class 2 Recycled Pavement Material shall be provided; and

Total asphalt thicknesses exceeding 150 mm

As for thicknesses 75 to 150 mm, except that an unbound granular base is not required.

8.3 Empirical Design of Granular Pavements with Thin Bituminous Surfacings

8.3.2 Pavement composition

As the traffic loading increases, the qualities and thicknesses of the base and subbase materials also needs to increase. Better quality materials are used in the upper levels of the pavement and a much wider choice of test property limits can be permitted for subbase.

Material properties and layer thicknesses for base and subbase layers are discussed below:

Base

Class 1 Quarried Pavement Material or Class 1 Recycled Pavement Material, as specified in the DPTI Master Specification for Roadworks 215 shall be used as base, with minimum thicknesses as follows:

- for design traffic of up to 10^6 ESA, a minimum thickness of 150 mm;
- for design traffic of 10^6 to 10^7 ESA, a minimum thickness of 250 mm; and
- for design traffic exceeding 10^7 ESA, a minimum thickness of 300 mm.

Subbase

A minimum 125 mm thickness of Class 2 Quarried Pavement Material or Class 2 Recycled Pavement Material shall be provided. In accordance with Table 6.16, lower subbase layers shall also comprise Class 2 Quarried Pavement Material, Class 2 Recycled Pavement Material, Class 3 Quarried Pavement Material, or Class 3 Recycled Pavement Material, or other approved granular materials of similar strength.

8.3.3 Geogrid reinforcement

Where appropriate, geogrids are provided at the interface of the subbase and subgrade. Reinforcement can be achieved from any one, or combination of the following mechanisms (Perkins et. al., 1998):

- Resistance to lateral spreading of the subbase aggregate as vertical loads are applied at the pavement surface.
- Increased confinement afforded to the subbase causing an increase in the state of stress in that layer and correspondingly an increase in the modulus of the subbase (and base) layers.
- Improved distribution of stress to the subgrade which generally results in the subgrade achieving a higher modulus.
- Reduced shear stresses being transferred to the subgrade resulting in lower vertical strains being mobilised in the subgrade.

To date DPTI has primarily used geogrids on soft subgrades as a construction expedient without any reduction in pavement thickness or strength requirements. This low risk approach reflects the lack of local performance studies, although there is some overseas experimental evidence that supports the use of a thickness reduction methodology for geogrids. As with other developing treatments, the DPTI usual practice would be to incorporate trial sections of limited extent within new construction works (subject to project and asset manager approval). These would assist the assessment of placement issues, economic viability, and field performance prior to widespread adoption of a new design approach.

8.3.4 Shoulders

For construction of sealed shoulders adjoining new pavement, the minimum total thickness of shoulder material shall not be less than that obtained from *Figure 8.4* using a design traffic value for the shoulders of 2-5% of the pavement design traffic value, as appropriate. Where the sealed shoulder is full lane width, an emergency stopping lane, or is likely to be frequently trafficked, 100% of the design traffic should be adopted.

8.3.5 Sprayed seal considerations

Table 3.2 in this Supplement should be used as a guide for the selection of initial spray seal treatments on granular pavements. Unless otherwise specified sprayed seal treatments shall be designed in accordance with Austroads Seal Design Procedures and the following exceptions and additions:

a) Sealing aggregate shall comply with the DPTI Master Specification, Part 215.

b) The size of aggregate selected will vary according to the expected volume and composition of traffic. In general, a 14/7 double seal is appropriate as an initial surfacing treatment on a granular pavement. However, where traffic volumes exceed 2000 vehicles/lane/day or the percentage of heavy vehicles exceeds 15%, a 16/7 double seal should be considered.

c) Primed surfaces on granular pavements shall be cured for a minimum of 3 days prior to applying the final surfacing. Cement treated bases shall be primed with a very light prime at a rate of 0.4 - 0.6 l/m^2 depending on the surface finish of the pavement.

d) All concrete bridge decks and concrete pavements that are to have a bituminous surfacing applied, shall first be primed with a very light prime at the rate of 0.2 – 0.3 l/m^2 depending on the surface texture and the finish of the concrete surface. The prime shall be allowed to cure for 3 days prior to the application of any subsequent surfacing treatment. It should be noted that some concrete curing compounds might react adversely with bitumen. If this is the case, the curing compound needs to be removed prior to the application of the prime.

   Where the final surfacing consists of asphalt, a 10mm S25E SAMI shall be applied over the prime at the rate of 1.6 – 1.8 l/m^2 for the full extent of the concrete surface.

e) For seal treatments on granular pavements, aggregate embedment can have a significant effect on binder application rates, and hence needs to be measured prior to final seal design. *Table 8.5* below provides general maximum limits for average ball penetration values at varying traffic volumes.

Table 8.5 Suggested Maximum Average Ball Penetration Values

Traffic Volumes (AADT/lane/day)	Ball Penetration (mm)
AADT/lane/day ≤ 1500	3.5
1500 < AADT/lane/day ≤ 2500	3.0
2500 < AADT/lane/day ≤ 3000	2.5
AADT/lane/day >3000	2.0

Note: The penetration values are a guide only, determination of an appropriate hardness value will depend on several factors including traffic composition, gradient and curve radii.

f) Where high traffic volumes require the use of low binder application rates, geotextile reinforced seals may be utilised to minimise the degree of aggregate embedment. However, this treatment should not be applied to areas subject to high shear forces such as intersections, tight corners and steep climbing lanes.

g) It is advisable to leave cutback primerseals exposed for 6 – 12 months. It is also recommended that cutback bitumen primerseals be trafficked for 3 months between October and March before placing a sprayed seal or asphalt surfacing less than 100 mm thick (refer Table 3.2).

   Where it is not feasible to comply with the above time constraints an emulsion primer binder may be used, in which case the final surfacing can be applied after the emulsion primerseal has been subjected to several weeks of trafficking in hot weather.

8.4 Mechanistic Procedure – Example Charts

These charts may be used in establishing a trial thickness for a given subgrade CBR and design traffic to commence the normal iterative mechanistic design procedure. They are based on selected design factors and their relevance to a particular project may be limited.

8.6 Documentation of Pavement Design Calculations

Flexible pavement designs shall be supported by documented design calculations and methodology, including:

- the subgrade and if relevant, selected subgrade material test results and procedures used to obtain design CBR values and hence layer moduli;
- the processes used to estimate the moduli for each pavement material;
- the design traffic calculations;
- the DPTI CIRWIN Summary Report or Mincad CIRCLY Job Summary File, with layer thicknesses, elastic properties and CIRCLY critical strains;
- the CIRCLY .clo output files;
- the performance relationships used to estimate allowable loadings;
- the allowable loadings for each distress mode; and
- adjustment of the governing layer thickness.

9 DESIGN OF NEW RIGID PAVEMENTS

9.1 General

The Roads and Maritime Services (RMS, formerly RTA) NSW is the pre-eminent Australian road authority in rigid pavement technology having designed, constructed and maintained the majority of Australian concrete pavements over the last 30 years. Given the extremely limited use of concrete roads in South Australia, DPTI relies heavily on RMS's recommended practices for the design of concrete pavements. Consequently, the following additional advice to the Guide was initially based on the RTA *Supplement to the Austroads Guide to the Structural Design of Road Pavements* (2005). This advice may be extended or superseded by RMS *Supplement* updates.

The Austroads design procedure assumes that the base and subbase will separate under traffic and environmental loading. Debonding procedures vary markedly according to both the type of subbase and the type of base (refer *Table 9.10* of Guide) and are detailed in RMS specifications. Local climatic conditions should also be taken into account. Appropriate debonding can be critical to the performance of the pavement.

Further information on materials, design and construction aspects are available in the RTA *Model Specifications* (for concrete pavements), RTA *User Guide to Concrete Pavement Specifications* (RTA 2001), and the RTA *Concrete Pavement Manual* (RTA 1991).

The Guide does not offer any guidance to the impact on settlement on pavement thickness and the designer should refer to RTA Technical Direction *Design Considerations for Concrete Pavements in Areas of Differential Settlement.*

9.2 Pavement Types

Refer to discussion in Section 2.2.2.

9.2.1 Base types

Roundabout Pavements

The design of roundabout pavements is a special case because the radii and vehicle speeds are vastly different to those normally encountered on the road network. This combination of radius and speed includes high centripetal forces and results in high outer wheel loads from commercial vehicles.

Special rules therefore apply to the design of roundabout pavements, whether designed in steel-fibre, mesh reinforced or plain concrete. These rules are subject to ongoing development and do not yet appear in the Guide.

The following advice applies principally to low speed urban roundabouts but the concepts should also be considered in designing rural roundabouts, and possibly even low radius curves.

Because of the typically radial pattern of jointing in a roundabout (and the resulting odd-shaped slabs) it is difficult to correctly align dowels and they are therefore usually avoided in this application.

The thickness design for steel fibre concrete pavements (SFCP), being an undowelled pavement, would normally be controlled by erosion and the thickness usually would therefore be the same as that for a plain undowelled pavement. However, the geometry of roundabouts usually results in relatively low traffic speeds. Joint distress is unlikely to be controlling factor in the pavement life. For heavy vehicle speeds below about 30 km/h, the thickness design is therefore carried out considering fatigue only.

The higher flexural strength of SFCP results in a significantly reduced stress ratio factor and lower percentage fatigue for a given pavement thickness.

Concrete Roundabout Pavements – A Guide to their Design and Construction (RTA 2004) provides additional design advice.

9.2.3 Wearing surfaces

Where an open graded asphalt wearing surface is required over continuously reinforced concrete pavements (CRCP), the minimum asphalt thickness is 60 mm, consisting of 30 mm of dense graded asphalt and a minimum 30 mm of open graded asphalt to allow future milling and resurfacing.

Thin asphalt wearing surfaces over a plain concrete base should be discouraged as the reflective cracking in these thin layers is difficult to maintain, even with a pre-treatment over the transverse contraction joint.

9.3 Factors used in Thickness Determination

9.3.3 Base concrete strength

For design traffic less than 10^6 HVAG a minimum 28-day characteristic compressive strength of 28 MPa is required to ensure adequate pavement surface durability. This equates to about 4 MPa concrete design flexural strength.

Steel fibre reinforced concrete pavement roundabouts are typically designed to a minimum 28-day flexural strength of 5.5 MPa (refer to Section 9.4.2).

9.3.5 Concrete shoulders

The Guide recognises the structural contribution of an integrally cast channel gutter or kerb and gutter. DPTI recommends that concrete shoulders always be incorporated in the design of rigid pavements.

A separately placed channel comprised of structural grade concrete may also provide edge support to the pavement, but to a lesser extent, and hence does not warrant a reduction in pavement thickness. Wherever heavy vehicles are likely to travel along this edge a "no shoulder" design condition should be adopted.

If kerbing cannot be constructed integrally, special effort is warranted to maximise the contribution of a tied kerb and gutter by:

- specifying a slipform kerb (in contrast to an extruded one); and
- providing tie bars with adequate pull-out embedment to ensure the maintenance of load transfer by aggregate interlock.

9.4 Base Thickness Design

9.4.1 General

To allow for variations in the constructed layer thicknesses within the construction tolerances, 10 mm shall be added to the design base thickness.

9.4.5 Example design charts

These charts may be used in establishing a trial thickness for a given subgrade CBR and design traffic to commence the base thickness design. They are based on selected design factors and their relevance to a particular project may be limited.

9.5 Reinforcement Design Procedure

9.5.2 Reinforcement in jointed unreinforced pavements

Jointed reinforced concrete slabs are usually 8 to 15 metres long, but lengths in the range 10 – 12 m are recommended on the basis of economy and pavement performance. In addition, slabs longer than about 12 m are likely to provide noticeably lower ride quality because of the necessarily wider transverse joints.

In steel fibre concrete pavements, slab lengths should be limited to 6 m in the case of undowelled joints and 10 m for dowelled joints.

9.5.4 Reinforcement in continuously reinforced concrete pavements

The proportion of longitudinal reinforcing steel (p) in a cross section, or steel ratio, is initially determined using *Equation 31* in the Guide. For example, in a typical Continuously Reinforced Concrete pavement using Y16 bars, assuming a crack width of 0.3 mm and a total shrinkage and temperature strain of 500 microstrain, the steel ratio is 0.67%. This is the minimum value of p.

The critical value of the proportion of reinforcing steel p_{crit} is determined by *Equation 33*. It is in inverse proportion to the yield strength of the steel and directly proportional to flexural strength of the concrete.

When flexural strengths are available from trial mixing of concrete to be supplied to the works, the proportion of reinforcing steel specified in the design should be checked using *Equation 33*. If the strength of the concrete is higher than anticipated the proportion of steel reinforcement will need to be increased or the base thickness reduced, provided the thickness design criteria are met.

Equation 34 of the Guide has been provided to determine the expected theoretical spacings of cracks. It is provided as a guide and is not to be used for design purposes under normal Australian climatic conditions to determine or adjust the required reinforcement.

9.7 Joint Types and Design

9.7.6 Joint Design

The design and layout of all pavement joints shall be carried out in accordance with RTA *Standard Concrete Pavement Drawings* (2010).

9.8 Documentation of Pavement Design Calculations

Rigid pavement designs shall be supported by documented design calculations and methodology, including:

- concrete pavement type, subbase type and whether or not concrete shoulders are to be provided;
- subgrade and if relevant, selected subgrade material test results and procedures used to obtain design CBR values and equivalent subgrade strength using *Equation 25* of the Guide;
- design traffic calculations, including expected load repetitions for each axle group load of each axle group type, in a format similar to *Table L.1* of Appendix L the Guide;
- calculations of allowable load repetitions and percentage damage for each axle group of each axle group type in a format similar to *Table L.2* of Appendix L of the Guide;
- adjustment of the calculated base layer thickness for construction tolerance; and
- the specified base thickness taking into account the minimum thicknesses in *Table 9.7* of the Guide.

For reinforced pavements, reinforcement design calculations in accordance with *Section 9.5* of the Guide shall also be provided.

The following project-specific drawings shall be provided:

- joint layout plans for the project;
- cross-sections including traffic lane widths, shoulder widths, the location of longitudinal joints in base and subbase, sub-surface drainage;
- detailed drawings of each joint type (e.g. transverse contraction, construction, longitudinal) and special features (e.g. slab anchors, terminals at bridge structures; reinforcement, kerb and channel joints, junctions of concrete and flexible pavements).

10 COMPARISON OF DESIGNS

10.1 General

The validity of the economic comparisons invariably depends on the accuracy of the numerous assumptions and performance predictions that need to be made within each pavement whole-of-life costing model. For real pavements, the field performance can vary significantly between projects and differ from the typical or base expectations. Hence, it will often be necessary to consider the economic comparisons for the scenarios where rehabilitation and maintenance requirements are consistently either more or less than the average case. A comprehensive analysis would include economic comparisons of pessimistic, base and optimistic performance predictions and their associated maintenance costs over the analysis period.

10.2 Method for Economic Comparison

The Present Worth of Costs (PWOC) method shall be used to calculate the Whole-of-Life costs.

10.6 Real Discount Rate

A discount rate of 7% shall be used with sensitivity testing at 4% and 10%.

10.8 Road User Costs

Consideration must be given to the safety and service of road users and others who may be affected by the presence of the asset. Some issues to consider are:

- Disruption caused by frequency of maintenance activity.
- Roughness impacts on the cost of operating vehicles.
- For strategic routes, implications of damage/disruption due to (perhaps low probability) catastrophic events (e.g. floods, earthquakes), subsidence, expansive subgrade etc.
- Traffic noise from particular surfaces.
- Environmental issues
  - During construction and maintenance
  - e.g. potential for dust, material disintegration or ravelling, fumes or contamination to the environment from certain road materials
- Aesthetic or visual intrusion effects.
- Traffic and pedestrian safety which may be affected by:
  - surfacings (texture, colour/visibility etc)
  - susceptibility of the pavement type to damage (e.g. rutting, cracking, ravelling)
- Practically of adopting a different pavement type on a road length which is dominantly of another pavement type.

Although cost is a prime consideration in the selection of options, if any of the above non-measurable factors are considered important for the project under consideration, judgement will have to be used and the most economic solution may not be the most appropriate.

11 IMPLEMENTATION OF DESIGN AND COLLECTION OF FEEDBACK

11.1 Implementation of Design

11.1.1 Pavement Work Schedule

The DPTI Master Specification for Roadworks Part 220 requires the Contractor to undertake pavement works in accordance with the Pavement Work Schedule for the project. *Tables 11.1*, *11.2* and *11.3* are examples of these Schedules.

The following guidance is included in this Supplement to assist pavement designers in preparing these Schedules.

Design levels

To allow for variations in the constructed layer thicknesses within the construction level tolerances, 10 mm shall be added to the pavement layer which governs the overall allowable loading.

Layer thickness shall conform to Section 3.7 and *Table 3.1* of this Supplement.

Level tolerances

- The level of the top of each asphalt course shall not differ from the Design level by more than 10 mm. Where asphalt is placed against kerb and channel the surface at the edge of the wearing course shall be flush with or not more than 5 mm above the lip of the channel. At other locations the tolerance on the wearing course shall be ± 5mm.
- The level of the top of each unbound granular pavement or cement stabilised layer shall not differ from the Design level by more than 15 mm.
- The level of the top of subgrade and Type A fill materials shall not be higher than the specified level and not lower than the Design level by more than 40 mm, or 20mm on projects where higher standards of uniformity are required.

Nominal compacted thicknesses

Refer to Section 3.7 of this Supplement for guidance on layer thicknesses.

Compaction Acceptance Criteria

- Asphalt layers shall comply with compaction criteria specified in Part 228 of the DPTI Master Specification for Roadworks.
- Plant mixed cement stabilised layers shall comply with compaction criteria specified in Part 222 of the DPTI Master Specification for Roadworks. For heavy-duty designs, a minimum 98% Modified Compaction shall be specified.
- Unbound granular base (PM1) layers shall be compacted uniformly to the full depth and over the full width to an L_s value of not less than 98%. (DPTI Master Specification for Roadworks Part 221).
- Unbound granular subbase (PM2) layers shall be compacted uniformly to the full depth and over the full width to L_s of not less than 96%.
- Fill materials shall comply with the compaction criteria specified in Part 210 of the DPTI Master Specification for Roadworks.

Table 11.1 Example of Pavement Schedule for an Asphalt Cemented Composite Pavement

Design Level of Upper Surface of Courses in Relation to Finished Design Levels (mm)	Level Tolerance (mm)	Nominal Compacted Thickness	Layer	Material	Application Rates and Additional Requirements to Master Specification – Division 2 Roadworks
00	+5, -0 (k&g) ±5 elsewhere				
-40	+5, -10	40mm	Wearing Course (1)	AC10M (3) A35P	
-95	±10	55mm	Levelling Course (1)	AC14M C320	
-175	±15	80mm	Base Course (1)	AC20M C320	
		5mm	SAMI	10mm S25E Spray Seal (2)	Aggregate: SA10-7, Spread rate 120m^2/m^3, Precoat: IDF++ @ 4 L/m^3 Binder: S25E @ 1.9 L/m^2, Adhesion add: 1 part.
-180	±15		Prime	AMC00 (2)	0.8 L/m^2
-495	+0, -20	315mm	Subbase	20mm Quarry Rubble with 4% Cement SPM2/20QGC4 (4)	96% Modified Compaction Placed in two layers & same day
			Subgrade		

KEY TO ABBREVIATIONS

(k&g) Kerb and gutter locations only.
L/m^2 Litres per square metre.
IDF++ 100parts IDF, 30 parts C170, 1.5 parts approved adhesion additive

Notes:
(1) Tack Coat (CRS60 @ 0.2 L/m^2 residual) to be applied in accordance with Part 228 Clause 6.4 or as directed by the Superintendent.
(2) Spray rates are nominal values only and may vary due to stone ALD, surface texture, weather conditions, etc. Rates are to be verified by the Superintendent prior to application.
(3) "H" - Heavy duty mix to be used for 50m approach to intersections (Refer Pavement Plans for locations).
(4) Recycled crushed concrete with 4.5% cement, i.e. SPM1/20RG, C4.5 may be used as an alternative.

PAVEMENT TYPE A

Table 11.2 Example Pavement Schedule for a Spray Sealed Unbound Granular Pavement

Design Level of Upper Surface of Courses in Relation to Finished Design Levels (mm)	Level Tolerance (mm)	Nominal Compacted Thickness	Layer	Material	Application Rates and Additional Requirements to Master Specification – Division 2 Roadworks
			Wearing Course	10/5 Double Sprayed Seal (1)	Aggregate:-10mm to SA10-7, Spread rate $120m^2/m^3$, Precoat: IDF++ @ 4 L/m^3, Binder:- C170 @ 1.0 L/m^2 Aggregate:-5mm to SA5-2, Spread rate $200m^2/m^3$, Precoat: IDF++ @ 4 L/m^3, Binder:- C170 @ 0.8 L/m^2
00	±10		Prime	AMC0 (1)	Application Rate @ 1.0 L/m^2
-150	±15	150mm	Base Course 1	20mm Crushed Rock (PM1/20)	98% Modified Compaction 60% OMC Dryback
-300	±15	150mm	Base Course 2	20mm Crushed Rock (PM1/20)	98% Modified Compaction
-450	+0, -40	150mm	Subbase	20mm Quarry Rubble (PM2/20)	96% Modified Compaction
			Subgrade		

KEY TO ABBREVIATIONS

L/m^2 Litres per square metre.

IDF++ 100parts IDF, 30 parts C170, 1.5 parts approved adhesion additive

Note: (1) Spray rates are nominal values only and may vary due to stone ALD, surface texture, weather conditions, etc. Rates are to be verified by the Superintendent prior to application.

PAVEMENT TYPE B

Table 11.3 Example of Pavement Schedule for a Full Depth Asphalt Pavement

Design Level of Upper Surface of Courses in Relation to Finished Design Levels (mm)	Level Tolerance (mm)	Nominal Compacted Thickness	Layer	Material	Application Rates and Additional Requirements to Master Specification – Division 2 Roadworks
45	±5				
		40mm	Wearing Course (1)	OG14 A15E(3)	
00	+5, -0 (k&g) +5, -10 elsewhere	5mm	SAMI	10mm S25E Spray Seal (2)(3)	Aggregate: SA10-7, Spread rate 120m^2/m^3, Precoat: IDF++ @ 4 L/m^3 Binder: S25E @ 1.9 L/m^2, Adhesion add: 1 part.
-40	±10	40mm	Levelling Course (1)	AC10M C320	
-95	±10	55mm	Intermediate Course (1)	AC14M C320	
-175	±10	80mm	Base Course (1)	AC20M C320	
		50mm	Lower Base Course (1)	AC14HB C320	
-225	+0, -10		Prime	AMC0 (2)	1.0 L/m^2
-375	+0, -20	150mm	Subbase	PM2/20	96% Modified Compaction
			Subgrade		

KEY TO ABBREVIATIONS

(k&g) Kerb and gutter locations only.
L/m^2 Litres per square metre.
IDF++ 100parts IDF, 30 parts C170, 1.5 parts approved adhesion additive

Notes:
(1) Tack Coat (CRS60 @ 0.2 L/m^2 residual) to be applied in accordance with Part 228 Clause 6.4 or as directed by the Superintendent.
(2) Spray rates are nominal values only and may vary due to stone ALD, surface texture, weather conditions, etc. Rates are to be verified by the Superintendent prior to application.
(3) AC10H A15E mix to be used and SAMI to be omitted within intersections and for 50m approach / departure to intersections (Refer Pavement Treatment Plans for locations).

PAVEMENT TYPE C

Moisture Content of Granular Materials

Unbound granular materials shall comply with the following moisture criteria prior to sealing or placement of an overlaying material:

- PM1 materials shall not have a moisture content exceeding 60% of optimum moisture content; and
- PM2 and PM3 materials shall not have a moisture content exceeding 70% of optimum moisture content.

11.1.2 Field assessment of materials during construction

As specified in Part 210, proof rolling is used to identify any unsuitable material (i.e. soft spots). When areas of weak materials occur, the dynamic cone penetrometer (DCP) may be used to determine their depth and lateral extent.

The Clegg Impact Soil Hammer (Clegg, 1980) commonly known as the Clegg Hammer is a field instrument for indirectly determining the insitu strength or stiffness of compacted materials. Queensland Transport Technical Note 5 *Application for Clegg Impact Soil Tester* provides target impact values that may be a useful guide in assessing the field strength and integrity of compacted unbound granular layers.

Measurement of the surface deflections on completed granular layers using the Falling Weight Deflectometer (FWD) may also provide a guide to the consistency and uniformity of the construction work at these stages. In addition, indications of the competency of the pavement during construction can be gained by considering the magnitude of the measured maximum deflections.

Ideally, the additional granular thickness required to reduce the measured maximum deflection to the design deflection should not exceed the total thickness of granular layers yet to be placed. Where this condition is not met, appropriate remedial action or design modifications can be implemented to ensure the required structural adequacy of the completed pavement.

11.1.3 Assessing the impacts of constructed roughness

For spray sealed granular pavements, *Figure 11.1* may be used to assess the impacts associated with different values of initial roughness that may be constructed into the pavement. The method involves considering the ratio of the terminal roughness (i.e. when the pavement shape needs to be corrected) to the constructed roughness.

When this ratio is less than 3, additional thickness of granular material is theoretically required to slow the progression of roughness to a rate that ensures the pavement does not reach the terminal value before the design traffic loading has occurred.

The additional thickness of granular material is calculated as follows:

- The ratio of the terminal to constructed roughness is calculated.
- Using this roughness ratio and the design traffic loading (ESA) determined in Section 7.6.3 of the Guide, the modified design traffic is estimated from *Figure 11.1*.
- Using *Figure 8.4* of the Guide, the difference in granular thickness using the design traffic and the modified design traffic loading is determined.

The required additional granular thickness is a measure of the impact of constructing spray sealed granular pavements with higher than anticipated initial roughness.

For example, consider the case where a sprayed seal granular pavement with design traffic loading of 10^6 ESA and subgrade Design CBR of 5%, has an initial constructed roughness of 75 counts/km. If the terminal roughness at which rehabilitation would commence is 150 counts/km, the ratio of terminal to initial roughness is 2. From *Figure 11.1* the modified design traffic loading is of 5.5×10^6 ESA. From *Figure 8.4* of the Guide, the required total granular thickness increases from 395 mm to 470 mm. That is, the effect of increasing the initial roughness from 50 counts/km to 75 counts/km is equivalent to requiring an additional 75 mm of granular thickness.

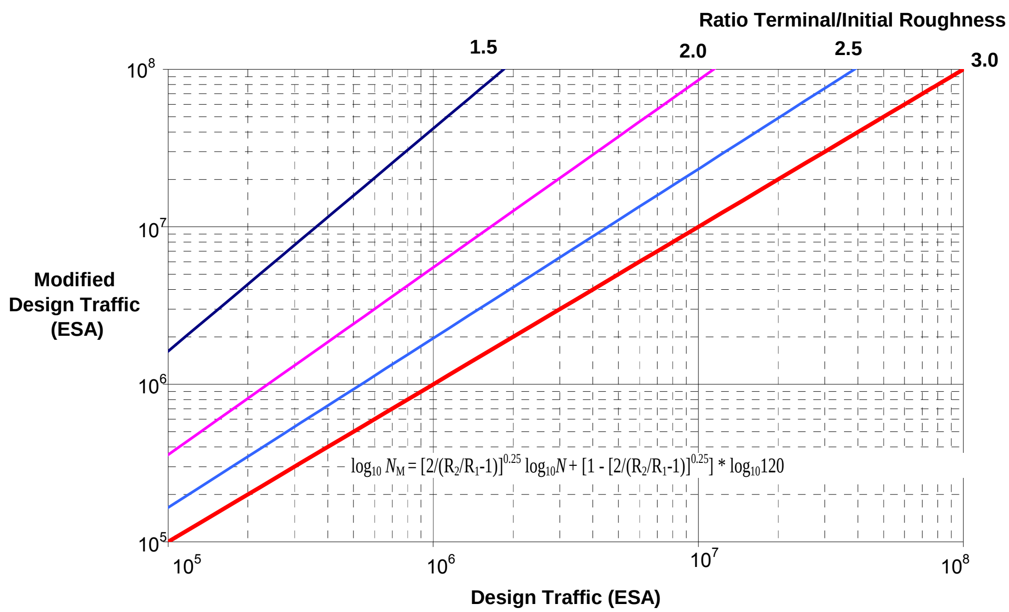

Figure 11.1 Modified Design Traffic for spray sealed granular pavements

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