Roads

Master Specification

RD-PV-D2 – Pavement Rehabilitation Design (Austroads Part 5 Supplement)

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4	Update to use of A5E PMB, reporting requirements, Hold Points and analysis of seasonal variation of skid resistance. Other minor updates to formatting.	August 2021

Document Management

Contents

RD-PV-D2 – Pavement Rehabilitation Design (Austroads Part 5 Supplement)

1 Introduction

1.1 This Part is a Supplement to the Austroads publication Guide to Pavement Technology Part 5 Pavement Evaluation and Treatment Design (2019).

1.2 The use of the term "Guide" in this document refers to the *Austroads Guide to Pavement Technology Part 5 Pavement Evaluation and Treatment Design*, while the term "Supplement" refers to this Department Master Specification Part.

1.3 This Master Specification Part provides direction when using the Austroads methodology to evaluate and design pavement rehabilitation treatments for the Department for Infrastructure and Transport (Department).

2 Scope of the Guide and this Part

2.1 Construction of pavement designs shall comply with the Department's Master Specification for Roads. Conformance with this Specification is a fundamental prerequisite to achieving the design parameters provided in this Supplement, and the pavement life.

2.2 Where there is a difference between content in the Guide and this Supplement, the requirements of this Supplement shall govern.

2.3 The Austroads Guide Part 5 and this Supplement are intended for the design of rehabilitation treatments for existing road pavements. Some projects may involve areas of existing and new pavement, for example, lane realignments, widenings and tie-ins with existing roads. The designer shall refer to the Austroads *Guide to Pavement Technology Part 2 – Pavement Structural Pavement Design (2017)* and the Department's Supplement to Part 2 (Part RD-PV-D1) for further guidance on the design of new pavements.

2.4 The Part 5 Guide refers designers to the Part 2 Guide for some design procedures, e.g. the mechanistic-empirical procedure (CIRCLY or AustPads). The Department's Part 2 Supplement RD-PV-D1 shall also be referenced when undertaking these designs.

3 Project Definition

Project Scope

3.1 As stated in the Guide, "…the project scope provides a framework for the required pavement investigation, analysis and design.…". Table 2.1 of the Guide outlines the major factors influencing project scope.

3.2 The desired pavement performance level (acceptable pavement performance risk) in combination with the existing site conditions are key factors influencing appropriate pavement design period, pavement treatments and their design parameters and surface characteristics. Development of alternative treatment options of different design period, project reliability, cost and risk (and other criteria) may be appropriate on some projects. As such, mandated pavement design periods cannot be prescribed in this Guide as it is project scope dependent.

3.3 The design periods in Table RD-PV-D2 3-1 are provided as an indication of the typical values adopted on Department pavement structural rehabilitation works. The design period for a specific project **must be approved by the Department** prior to commencing the investigation and design.

Table RD-PV-D2 3-1 Typical Pavement Design Periods for Structural Rehabilitation Treatments

Road Classification	Design Period – Flexible Pavements (years)	Design Period – Rigid Pavements (years)
Motorway– main alignment and ramps	30	Project specific assessment required
Urban & Rural Arterial, Urban & Rural Connector	20	
Access	20	

Note: Access roads would also typically apply to Local Government Roads, but this must be verified with the relevant Local Government authority.

3.4 Where projects include a combination of new pavements and existing pavement rehabilitation works. It is preferable to have the same pavement design period for all pavement works within the project, whether new or rehabilitation treatments, to avoid design, construction, performance and contractual complexities, inconsistencies, and other problems.

3.5 However, adoption of different design periods for new works and rehabilitation treatments may be appropriate in some instances. For example:

a) if a new full lane width overtaking lane (design life 30 years) is being constructed adjacent to existing pavements;

b) these existing pavements are sound at the time of the project, but may not theoretically achieve the 30 year design period of the new works;

c) the new traffic control layout won’t affect the existing pavements, particularly by increasing the traffic loading;

d) only resurfacing or minor shape correction of the existing pavement is required, e.g. reseal or asphalt overlay; and

e) then a lesser design period may be appropriate for the existing pavements, to avoid reconstructing them to achieve a 30 year design period.

3.6 In this type of situation, development of different design periods for different lanes, or carriageways, or other road elements must involve careful consideration of design, performance, and construction impacts, with approval by the Department.

3.7 For reference, important project scope inputs from this Supplement are listed below. These should be clearly established for each road element and pavement prior to commencing a pavement design.

a) Project Reliability;

b) Pavement Design Period for each road element and related pavements;

c) Pavement Design Extents;

d) Traffic Data;

e) Site Investigation Scope;

f) Any proposed design inputs that are non-conforming with the Austroads Guides and the Department’s Pavement Design Supplements, such as material modulus values, fatigue relationships, modulus or fatigue adjustment factors and so on;

g) Any other assumptions or critical design inputs made affecting the pavement design.

Acceptable Risk

General

3.8 The selection of appropriate pavement rehabilitation treatments requires knowledge and experience of configuration details and materials that have previously proven successful on Department projects. The design, construction and performance of pavement treatment types that are first time applications for the Department, for example new asphalt mixes, stabilisation binders or other technology transfer, are likely to involve additional risk factors that require careful consideration. Additional testing, design, construction monitoring, and post-construction performance monitoring would typically be required as part of their acceptance on Department projects.

Asphalt – Cement Treated Composite Pavements

3.9 Configurations with thick asphalt (150+ mm) over 2 cemented layers (280+ mm total) placed on the same day, have been constructed in and around Adelaide since about 1989. The sound structural performance of these pavements is critically dependent on the continued bonding of cemented layers, how this may deteriorate with load repetitions and environmental factors is not well understood, but it has been the Department's experience that the risk of debonding and the resulting extent and severity of distress increases significantly with higher traffic loadings. Further discussion is provided in RD-PV-D1 Section 3. Structural rehabilitation of these pavement types needs special consideration of possible debonding issues and it may be necessary to remove the full thickness of asphalt and upper cement treated layer to remove the issue, irrespective of outputs from the Austroads design system. Application of the Austroads and this Supplements asphalt overlay and heavy patching methods is not appropriate for this pavement type.

3.10 The assessment of debonding typically requires coring of the asphalt and cement treated layers to assess the interface condition. For major rehabilitation works, profiling larger test pits is preferred to better expose conditions.

Design Reliability

3.11 Apart from the chart-based approach to overlay design (Supplement, Section 7), the design of flexible pavement strengthening treatments utilises the same mechanistic-empirical design procedures used with new flexible pavements, as per Austroads (2017).

3.12 These methods allow pavements to be designed to a desired reliability level of outlasting the design traffic.

3.13 Minimum project reliability levels to be used for the design of rehabilitation strengthening treatments on Department roads are shown in Table RD-PV-D2 3-2.

Table RD-PV-D2 3-2 Minimum project reliability levels for rehabilitation treatments

Road Class	Project Reliability (%)
Motorway	95
Urban & Rural Arterial, Urban & Rural Connector	95
Access	90

4 Pavement Data

General

4.1 The Department's iTIMS intranet website contains a number of interactive road maps and databases from which the following information for the Department's road network may be obtained:

a) Road Features File: running distance location of significant features (e.g. side streets, bridges, culverts, speed limit signs, maintenance marker pegs).

b) Traffic information: AADT, percentage of commercial or heavy vehicles, weigh-in-motion reports, which may include current and older counts, allowing back calculation of historical growth rates.

c) Pavement condition: roughness, rutting, texture, cracking and skid resistance (grip number).

d) Pavement age and type.

e) Surfacing age and type.

f) Lane configuration and lane width.

g) Soil reactivity.

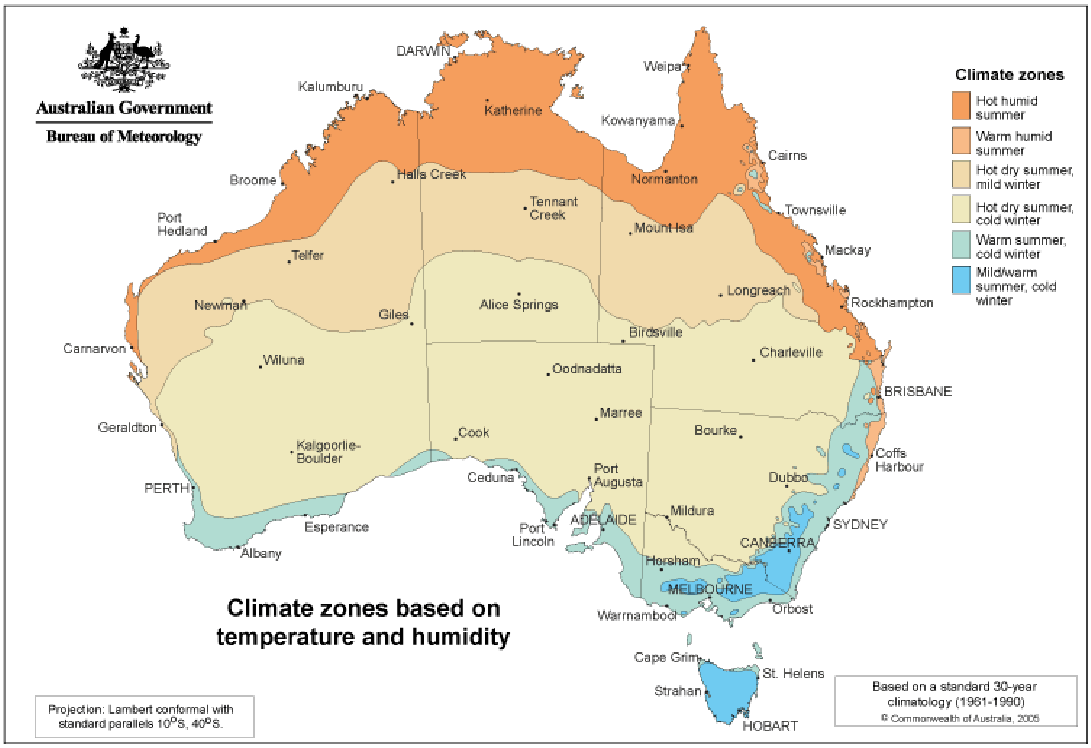
4.2 This intranet site is not publicly available but project specific data may be provided by the Department upon request. Where provided, it shall not be relied upon as being wholly accurate, but used as general information needing validation.

Historical Data

Climatic Conditions

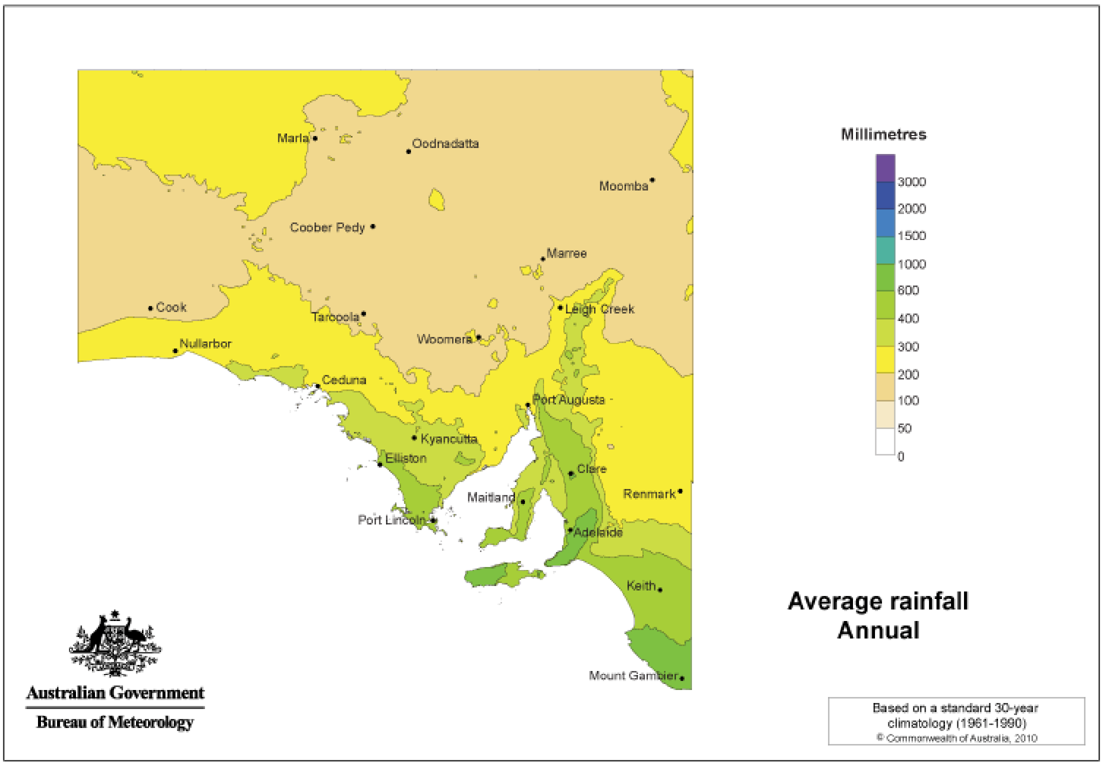
4.3 Australian climatic zones based on temperature and humidity are indicated in Figure RD-PV-D2 4-1 and the average rainfall and evaporation values are shown in Figure RD-PV-D2 4-2 and Figure RD-PV-D2 4-3 respectively.

Figure RD-PV-D2 4-1 Australian Climatic Zones



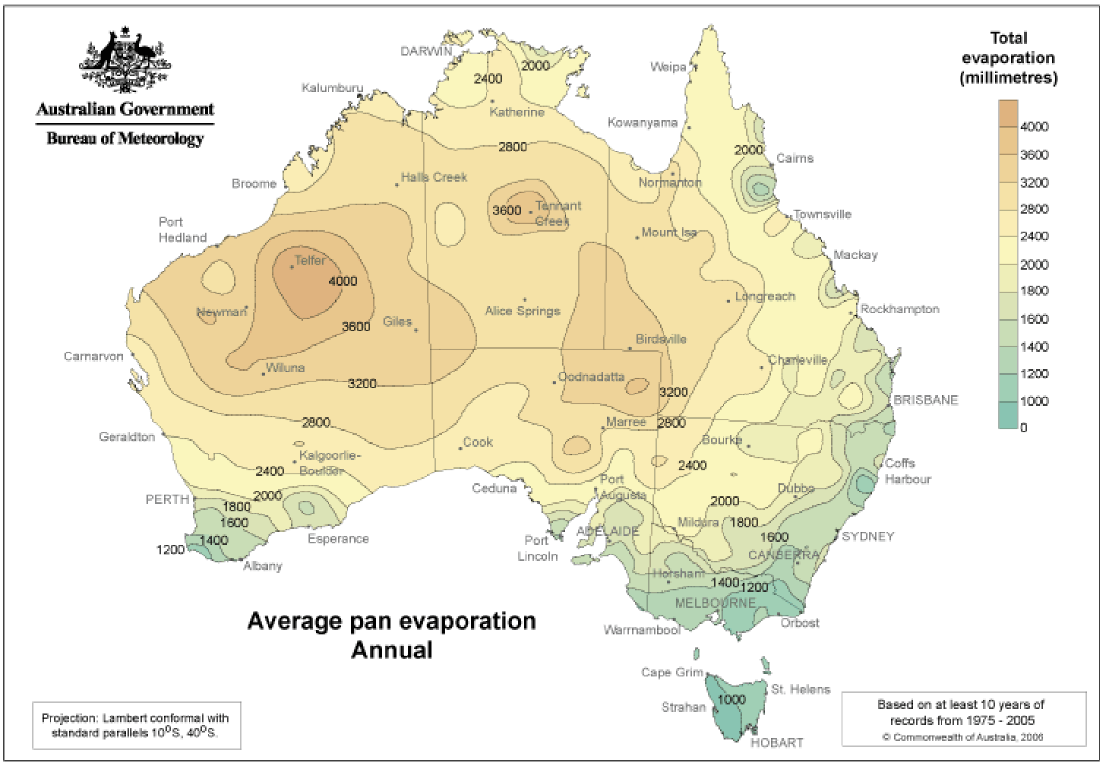
Source: Commonwealth Bureau of Meteorology 2005, copyright Commonwealth of Australia reproduced by permission. (www.bom.gov.au/climate

Figure RD-PV-D2 4-2 Average Annual Rainfalls for South Australia



Source: Commonwealth Bureau of Meteorology 2010, copyright Commonwealth of Australia reproduced by permission. (www.bom.gov.au/climate

Figure RD-PV-D2 4-3 Average Evaporation Map - Annual



Source: Commonwealth Bureau of Meteorology 2006, copyright Commonwealth of Australia reproduced by permission.(www.bom.gov.au/climate

4.4 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.

4.5 South Australia is relatively dry compared to other Australian states and typically has low rainfall and high evaporation rates. Except for the south east corner of South Australia, the remainder is wholly arid or semi-arid. The south east and Adelaide regions have dry summers with median annual rainfall of 400 – 800 mm, mostly in the winter months.

5 Investigative Testing and Site Inspection

Introduction

5.1 Completing a site inspection is a critical part of assessing the existing pavement condition and informing treatment selection and design. Appendix A of the Guide provides a system for the description and assessment of visual distress, which shall be utilised on Department projects.

5.2 The designer is expected to complete an initial inspection of the site as part of preparing the design and follow up with a final check of assigned pavement treatments as part of design verification.

5.3 Department projects require a site-specific pavement and subgrade investigation. This includes projects that interface with existing Department road assets, and new works that will become Department assets, both of which must be investigated, designed, and constructed to Department standards.

5.4 The site investigation and the associated laboratory testing has several objectives:

a) Identifying / confirming the causes of the pavement distress and deficiencies in the existing pavement, and their spatial variability, or validating the presence of sound pavement, informing candidate treatment selection.

b) Providing necessary data for pavement design, including:

   i) selection of pavement design parameters and inputs, such as existing pavement configurations, remnant pavement layer materials and thickness, layer moduli and subgrade design CBR;

   ii) test data directly used in design methods, e.g. deflection testing for use with Austroads overlay design methods; and

   iii) information for the design of other details like pavement joints and subsurface drains and expansive clay subgrade treatments.

c) Identifying potential construction issues and risks, e.g. wet, weak subgrades, strongly cemented layers, coarse macadam layers, uncontrolled fill.

5.5 It is therefore critical that the investigation and testing scope is properly developed and aligns with the project scope. Deficient investigations increase the risk of inappropriate treatment selection and/or design input selection, leading to excessively risky or conservative (costly) designs.

5.6 The following sections provide further information on acceptable investigation scopes on Department projects.

Skid Resistance and Texture Depth Data

5.7 The Department uses the Griptester to evaluate skid resistance and the multi-laser to evaluate surface texture. The Austroads *Guide to Asset Management – Technical Information Part 15: Technical Supplements (2018)* describes the Griptester and multi-laser and their method of operation.

Using Skid Resistance and Texture Depth Data

5.8 The Department investigatory levels of skid resistance as measured with the Griptester are given in Table RD-PV-D2 5-1.

Table RD-PV-D2 5-1 Investigatory skid resistance levels

Road Situation & Classification	Approximate Minimum Grip No.	Maximum Vehicle Speed km/h
Difficult sites - steep grades, intersection approaches, tight bends, roundabouts.	0.50	60
	0.55	80
Urban Arterial and Urban Connector Roads	0.45	60
Motorway, Rural Arterial and Rural Connector Roads	0.45	110
Access Roads	0.40	60

Note. The approximate conversion between British Pendulum No. and the Grip No. is Grip No.= 0.01 × BP

5.9 Skid resistance of spray seals, open grade and stone mastic asphalt wearing courses using South Australian aggregates before 2010 have demonstrated a seasonal variation in Grip Numbers. This is documented in van Loon (2014).

5.10 Surface texture has an important effect on the friction available to high speed vehicles, particularly in wet conditions (Austroads 2005). Table RD-PV-D2 5-2 provides investigatory levels. As the speed of a vehicle increases, it becomes more difficult to displace water from beneath the tyre until, in the limiting case, the tyre hydroplanes and braking and directional control are completely lost.

5.11 The reduction in skid resistance resulting from increased speed on wet surfaces is minimised when there are good drainage paths for the water. These are normally provided by both the tyre tread pattern and the surface texture of the road.

Table RD-PV-D2 5-2 Investigatory Surface Texture Levels

Road Type	Minimum Texture Depth in Wheel Path (mm) (Sand Patch Equivalent)
Motorway, Rural Arterial and Rural Connector Roads, Urban Arterial and Urban Connector Roads (80 km/hr or faster). Urban Arterial and Urban Connector Roads subject to stopping and turning (<80 km/hr)	0.6
Urban Arterial and Urban Connector Roads, Rural Arterial and Rural Connector Roads, Access Roads (<80 km/hr)	0.3

Surface Deflection of Flexible Pavements

Methods of Testing

5.12 The Deflectograph is to be used for deflection testing pavements that have been scheduled for rehabilitation. The data is cost-effectively collected at closely spaced intervals (about 4 m) along both wheel paths.

5.13 The Falling Weight Deflectometer (FWD) may be more suitable in the following situations:

a) Asphalt overlays for strengthening pavements with cemented materials or a design traffic loading exceeding 10^7 ESA are designed using the mechanistic-empirical procedures in the Guide. For these projects, the Deflectograph can be used to provide comprehensive information about the distribution of pavement strength along the project. Further testing with the FWD can be undertaken at selected locations for use in back-analysis procedures to better understand the past performance and assist in the detailed design of strengthening treatments.

b) Pavements with thick and stiff bound materials often produce very low Deflectograph deflections. FWD deflection testing at a higher contact stress of 1132 kPa (80 kN) in addition to the standard 566 kPa (40 kN) loading, may reduce deflection measurement errors and improve moduli estimates from back-analysis.

c) Projects which are short in length or are difficult to access with the Deflectograph.

d) Testing of unsealed pavements, including unsealed shoulders.

Selection of Test Sites

5.14 For projects where FWD deflections are not complemented by detailed Deflectograph data, the spacing of individual test sites is arranged so that the general variability or deflection trends can be identified.

5.15 For projects less than 2 km in length, FWD measurements shall be taken at 10 m spacings in both wheel paths of each test lane.

5.16 For projects greater than 2 lane km in length, the spacing of test points may be increased to 20 to 50 m, with closer spacings required where the existing pavement condition, known pavements types, support conditions, traffic loading, road geometry, etc are more variable. Staggering of testing in each lane of undivided rural roads with the same pavement composition and conditions in both lanes can be considered, depending on nominated test spacings. Testing intervals for rural road shoulders may be increased further, subject to review of shoulder variability along the project section.

Existing Pavement Composition and Material Quality

Pavement Composition and Material Quality Data

5.17 Identifying the existing pavement composition and subgrade conditions is a key requirement for understanding the pavement behaviour, selecting pavement treatments and undertaking design.

5.18 For this purpose, boreholes or test pits are excavated through the existing pavements to view and log the existing pavement and subgrade composition, undertake field testing and collect samples for laboratory testing.

5.19 The works undertaken at each borehole or test pit location is provided in Table RD-PV-D2 5-3. This has been taken from previous Department Geotechnical Site and Laboratory Testing Services contracts and represents the minimum standard of works required on Department projects. Additional comments and considerations not included in these contracts are provided in the second column of Table RD-PV-D2 5-3, as additional guidance.

Investigation Locations

5.20 The optimal investigation frequency and locations will depend upon project specific considerations, including:

a) the project scope and desired performance outcomes (acceptable performance risk);

b) the investigation cost versus the project scope and the impact on pavement design and construction cost;

c) candidate rehabilitation treatment options, and the data required for further assessment of their suitability and detailed design;

d) observed or inferred variability / uniformity of:

   i) existing pavement condition;

   ii) road geometry, including number of lanes, curves, grades and presence of cut or fill;

   iii) general topography and vegetation;

   iv) likely subgrade soils and regional geology;

   v) drainage and moisture conditions;

   vi) underground services;

   vii) known construction and maintenance history, including widenings and service works; and

   viii) deflection or other pavement condition test data (skid resistance, rutting, texture, cracking, etc.).

e) anticipated number of pavement treatment types and their extents.

5.21 Table RD-PV-D2 5-4 provides investigation frequencies for common Department rehabilitation project types. These spacings apply to the main road pavement only. Additional investigations will be needed at intersections, turn lanes, widenings and other road elements, where different pavement and subgrade conditions may be present.

5.22 It is often useful to compare areas of sound and distressed pavement to determine whether variations in the pavement composition or support conditions have contributed to the difference in performance.

Table RD-PV-D2 5-3 Borehole / Test Pit Site Requirements

Geotechnical & Pavement Investigation Requirement	Comments
Exposure of the pavement and subgrade materials by borehole[(a)] to a nominal depth of 1.5 m with a minimum natural subgrade penetration of 0.5 m, at the nominated test locations[(b)]. Any bituminous surfacings to be cored[(c)], with the cores retained, numbered and forwarded to the Department, if nominated by the Department. Coring may also be required on other fully bound materials, e.g. foam bitumen stabilised or cement treated layers.	a) a borehole excavated with a drill rig is preferred due to reduced disturbance of the existing pavement and easier reinstatement. However, test pits excavated with a backhoe or excavator may be more appropriate in some situations, e.g. shoulder investigations. Larger diameter boreholes are necessary where coarser pavement materials are present, e.g. macadams or to obtain larger bulk samples for laboratory testing. b) the Department may assign investigation locations, or otherwise the designer should choose (see Clauses 5.20 to 5.22 of this Supplement). c) To determine the thickness and quality of the asphalt layers for design and construction planning purposes. Coring increases investigation time and cost, and may not add value and be necessary when the results won't affect the treatment assessment and design. Cores can be invaluable when assessing issues with fully bound materials, like potential debonding of asphalt layers, the porosity of asphalt layers, depths of cracking and identifying lower density zones in asphalt or cement treated layers.
Engineering logging of: Pavement layers[(d)], including identification of sprayed seal surfacings, asphalt layers, granular layers, fully bound layers and any primes, or other interlayers. Soil strata, including the distinction between natural or fill materials, in accordance with AS1726 – 2017 Geotechnical Site Investigations, as a minimum standard. Identification of moisture conditions in each layer.	d) Identification of different pavement layers and material types is a critical requirement of the investigation and must be done with due care. Failure to identify materials like marginal materials, macadam, fully bound layers, wet subgrades, etc, may lead to inappropriate design and construction outcomes at increased cost.
Sampling as appropriate for laboratory testing and identification.	e) See below for further comment on laboratory testing requirements.
Dynamic Cone Penetrometer (DCP) testing of fill / subgrade materials at each bore hole location to 1.5 m[(f)] measuring penetration per blow, in accordance with AS1289.0 – 2000 Methods of Testing Soils for Engineering Purposes – General requirements and list of methods, Section 6.3.2, and determination of in situ CBR by the Guide Figure 5.5, relationship[(g)].	f) Deeper DCP testing may be required in deeper deposits of weaker material. g) Presentation of the results in accordance with the Principal's macro may be required on some projects (can be provided on request).
Hand Pocket Penetrometer (PP) readings of cohesive soils, with test results and inferred consistency shown on the logs at the relevant depth.	

Table RD-PV-D2 5-4 Indicative Investigation Locations

Rehabilitation Project Scope	Typical Locations
Asphalt Overlay / P&R	Asphalt cores typically at 150 to 200 m spacing, maximum 250 m spacing. Consider need to core each lane on multi-lane roads. 1.5 m boreholes at selected core locations, typically 300 to 400 m spacing, maximum 500 m spacing.
Sprayed Seal Granular Overlay	1.5 m boreholes typically at 200 to 300 m spacing, maximum 350 m spacing. Coring only undertaken where asphalt surfacings are present.
In Situ Stabilisation	1.5 m boreholes typically at 150 to 200 m spacing, maximum 300 m spacing.

Laboratory Testing

5.23 Sufficient sampling and laboratory testing of the pavement and subgrade materials shall be undertaken to attain adequate representation of the pavement, subgrade and any fill materials. Samples for laboratory CBR testing are typically concentrated on the governing subgrades and fills, allowing for the anticipated pavement founding level. Subgrade sample selection shall concentrate on materials most likely to provide the poorest support.

5.24 It may be necessary to adjust the nominal investigation scope (e.g. increasing frequency for more variable conditions) and sampling depths in response to observed ground conditions during the investigation, e.g. in order to avoid sampling across layer boundaries or to better target weaker materials governing pavement design parameter selection.

5.25 Testing must be undertaken in a NATA accredited laboratory in accordance with the relevant parts of AS1289 - Methods of Testing Soils for Engineering Purposes, or the appropriate testing standard.

5.26 Table RD-PV-D2 5-5 states the typical test types and conditions adopted on Department projects. Other laboratory testing may be appropriate depending on the pavement issues being investigated. Similarly, the test conditions may be varied, to better align testing conditions with anticipated field conditions in-service or meet other project needs.

Table RD-PV-D2 5-5 Typical Laboratory Test Types

Laboratory Test	Test Conditions and Comments	Requirement
4-day soaked CBR on remoulded samples	As per AS1289. Test specimens remoulded to 98% Standard compaction, OMC with 4.5 kg surcharge during soak & swell and penetration testing phases.	Mandatory
Estimated CBR	Department MAT-TP133 method, where an estimate of the CBR is obtained from Atterberg Limit and Particle Size Distribution tests (AS1289). This test is useful in providing both a soil classification and estimate of CBR from a single sample, but a lower weighting shall be given to these CBR results versus the 4-day soaked CBR values. The importance of field moisture contents in clayey materials is stressed particularly as a ratio of the Plastic Limit.	Project Specific
Atterberg Limits and Particle Size Distribution	As per AS1289. Used to assess existing pavement material quality and suitability for in situ stabilisation, as well as confirm field visual-tactile logs. Similarly, confirm visual tactile classifications for subgrade materials, and suitability for reuse in select fill or other considerations, e.g. expansive nature.	Project Specific
Moisture Content	As per AS1289. To assess field moisture conditions.	Project Specific
Stabilisation Mix Design	Laboratory mix design of stabilisation treatments typically requires collection of a large volume of pavement materials. Testing requirements are determined based on proposed depth and type of stabilisation and corresponding test methods.	Project Specific

Using Pavement Composition and Material Quality Data

Granular Materials

5.27 In assessing the quality of existing granular materials, laboratory test properties shall be compared to the pavement material requirements of the Department's Master Specification Part RD-PV-S1 "Supply of Pavement Materials".

5.28 The conformance with these specifications will then inform the assignment of design parameters like elastic modulus in mechanistic modelling with CIRCLY.

6 Selection of Treatments for Flexible Pavements

Treatments to Improve Drainage

General

6.1 Due to the relatively low rainfall and high evaporation rates in South Australia, sub-surface drains are generally not provided for pavements except on Motorways, or where groundwater issues are identified. These situations include semi/permeable face and or substrate and areas where the median or verge irrigation may lead to water entering the pavement.

6.2 Ground water site investigations shall 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.

Treatments for Surfacing Distress

Sprayed Seals

6.3 The detailed design of sprayed seal surfacings is beyond the scope of AGPT-5 and this Supplement. The Department requires seal design to be undertaken in accordance with Part RD-BP-D2 Design of Sprayed Bituminous Surfacing.

6.4 For background reference only, commentary to the application of sprayed bituminous surfacing in South Australia is available in a previous version of the Department's Master Specification, Part_R26_Guidelines.pdf, at the following weblink:

Division R Roadworks - Pre 1 July 2018 - Department for Infrastructure and Transport - South Australia (dit.sa.gov.au):

a) https://www.dit.sa.gov.au/contractor_documents/specifications_-_division_R_roadworks/

6.5 In general, the selection of an appropriate sprayed seal as a rehabilitation treatment depends primarily on the traffic volume and composition, and the condition of the existing pavement (including strength, cracking, texture and site location).

6.6 Where the pavement is showing only age-related signs of distress such as plucking or stripping of aggregate, a C170 binder may be adequate. However, over cracked pavements or in areas of high stress a polymer modified binder (PMB) may be needed. Guidance on the selection of the most appropriate PMB is provided in Austroads *Part 4K Seals (2018).*

6.7 For severely cracked pavements, particularly under heavy traffic (>15% EVH) the use of a PMB alone may not be sufficient to waterproof the pavement. In these situations, a double (14/7 or 16/7) geotextile seal shall be used, subject to the following conditions:

a) They must not be placed in areas subject to high shear forces such as intersections, tight corners and steep climbing lanes.

b) Application shall be restricted to the months of November to March inclusive.

c) Fabric overlap must conform with manufacturers specifications.

6.8 Where a granular overlay is being constructed under traffic, it is usually not possible to prime and seal the pavement, and a primerseal would be required. It is advisable to leave cutback primerseals exposed for 6 – 12 months, ensuring they are trafficked for 3 months between October and March, before placing a sprayed seal or asphalt surfacing less than 100 mm thick (refer Part RD-PV-D1 "Pavement Design", Table RD-PV-D1 3-6). 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.

6.9 Further direction is provided in Part RD-PV-D1 "Pavement Design", the *Guide to Pavement Technology Part 3 Pavement Surfacings* (Austroads 2009a) and *Guide to Pavement Technology Part 4K Seals* (Austroads 2018).

SAMI Treatment

6.10 A strain alleviating membrane interlayer (SAMI), generally size 10 mm S25E at 1.8 – 2.0 L/m^2, shall be applied on top of cemented material subbase layers under an asphalt base to inhibit reflection cracking. The thickness of a SAMI shall not be included in the design pavement thickness.

6.11 The aggregate applied with a SAMI is intended to protect the binder from trafficking prior to placing the overlying asphalt. As such, a lower aggregate application rate is acceptable, as necessary to avoid tyre to binder contact.

Asphalt Overlay

6.12 Part RD-PV-D1 Table 3-4 Guide to the Selection of Asphalt Types, shall be referred to for the selection of asphalt types, unless otherwise noted here in this Supplement.

6.13 Asphalt overlays may comprise a single or multiple layer configuration. Single layer overlays are typically used to restore the pavement surface, with the benefit of some minor strengthening and shape correction. A thicker, multiple layer asphalt overlay / inlay is adopted where substantial strengthening is needed, in addition to wearing course renewal and shape correction. The required overlay thickness is primarily dependent on the pavement design period and the existing pavement condition and strength. It is fundamental that the need for any strengthening or pre-treatment is assessed where a single layer asphalt overlay is being considered to avoid premature failure of the overlay from deficiencies in the existing pavement, such as reflection cracking. For example, crack sealing, use of fabrics or deeper asphalt patching may be necessary pre-treatments.

6.14 Where pavement strengthening requires use of a thicker multiple layer configuration, there are benefits in constructing this as an overlay rather than as asphalt P&R including:

a) avoiding excavating the existing pavement, and the risk of disturbing and weakening the existing materials, or exposing subgrade soils, as well as greatly reduced materials needing disposal;

b) reduced risk of clashes with underground services; and

c) the treatment increases the total pavement thickness.

6.15 However, level constraints on existing roads will typically limit this option to rural roads with no kerb and gutter. Where a thick overlay is viable the related consequences must be considered as part of the design, including geometric design (cross falls, superelevation, side road and entrance connections), drainage and shoulder works needed to match the higher overlay surface level.

6.16 Overlays in urban areas are typically level constrained by existing kerb and gutter levels and other surface features, and therefore limited to ~40 mm thickness, unless a special process requires 45 mm (Part RD-BP-C3). Edge planing (profiling) can be undertaken to match the level of the concrete channel and avoid a lip that can be hazardous to road users. The impact on overall pavement cross-section shall also be considered to ensure avoid creating other issues, e.g. driveway access issues from increased cross-fall.

6.17 An A15E modified binder (and in some situations A5E) is generally used in these thin-asphalt overlay resurfacings because of their superior performance compared to conventional binders. Part RD-PV-D1 Table 3-4 provides further guidance for the selection of asphalt surfacing types.

Open Graded Asphalt Surfacing & SAMI

6.18 As per Part RD-PV-D1 Table 3-4, open graded asphalt (OGA) must include A15E binder to extend the service life and to enhance structural integrity and stone retention.

6.19 A 10 mm S25E (1.8 – 2.0 L/m^2) SAMI is required under OGA surfacings to provide water proofing. The SAMI may also be required to rejuvenate the underlying asphalt.

6.20 In most situations OGA surfacings are terminated at the edge of the concrete channel and not extended to the kerb face. If minimising the edge drop is of high priority for the safety of cyclists etc, then edge planing of the existing asphalt to a depth of 10 mm prior to overlay is an acceptable option. The effect of the remaining level difference can be further reduced by “rolling over” the edge of the OGA overlay.

6.21 OGA can have lower early life skid resistance than other mixes until the binder film wears off the aggregate. The Department’s Master Specification for Roads Part RD-BP-D4 skid resistance requirements must be achieved. Placement of OGA between April to October, inclusive, is to be avoided, or a special process implemented to verify and ensure that adequate early life skid resistance is achieved, with appropriate site management implemented prior to this to ensure safety.

6.22 Rehabilitation works utilising an OGA wearing course also require reinstatement of the SAMI water proofing membrane below the OGA.

6.23 For multiple layer asphalt works, the new SAMI and OGA shall be placed on a new dense graded asphalt levelling course. This new asphalt shall form a flat, even surface that is suitable for SAMI construction and also avoid ponding of water on the SAMI surface from an uneven surface.

6.24 Alternatively, the pavement may only need replacement of the OGA wearing course only. For example, where the OGA is aged and ravelling, but the pavement data indicates a sound pavement structure. These works also require placement of a new SAMI below the new OGA wearing course. The designer may consider a design that profiles to just below the existing OGA and SAMI thickness, with the new SAMI and OGA placed on the profiled surface. However, in the Department's experience, several problems can arise with this approach, including:

a) the asphalt directly below the existing SAMI has accelerated binder aging and strength from its exposure to water and air within the OGA, which requires replacement. This weaker asphalt can also be prone to plucking and delamination during profiling;

b) the profiled surface can have a high texture and uneven surface, which can lead uneven SAMI application rates from drain down, and also inhibit future drainage of water from within the OGA;

c) The as-constructed thickness of the existing SAMI and OGA can vary substantially, with profiling leaving behind areas of remnant SAMI, that require rectification; and

d) Use of a dense graded levelling course below the new SAMI and OGA wearing course is therefore required by the Department, to provide an even surface below the SAMI and OGA. The minimum treatment is then profiling to allow reinstatement of a single layer of DGA + SAMI + OGA.

e) It is noted that on some projects, the combination of:

   i) using a finer profiling drum;

   ii) careful profiler operation;

   iii) use of a project specific specification defining the maximum allowable texture on the profiled surface; and

   iv) careful inspection of the profiled surface and rectification of deficient areas prior to SAMI sealing,

   has allowed successful placement of a SAMI directly on to the profiled surface. Use of this approach requires approval by the Department.

Stone Mastic Asphalt

6.25 Generally, size 10 mm stone mastic asphalt (SMA) is used as a surfacing layer, of 40 mm thickness, and incorporating A5E binder (A15E may also be approved).

6.26 To inhibit ingress of surface water to the pavement, a size 7 or 10 mm sprayed seal or SAMI is required under SMA10 surfacings, unless the nominal design thickness is equal or greater than 45mm and the in-situ specification RD-BP-C3 voids target range of 1.0-5.0% is achieved.

6.27 SMA can have lower early life skid resistance than other mixes until the binder film wears off the aggregate. The Department's Master Specification for Roads Part RD-BP-D4 skid resistance requirements must be achieved. Placement of SMA between April to October, inclusive, is to be avoided, or a special process implemented to verify and ensure that adequate early life skid resistance is achieved, with appropriate site management implemented prior to this to ensure safety.

Ultra-thin Asphalt Surfacings

6.28 Ultra-thin surfacings are generally only used by the Department on lightly to moderately trafficked roads (of less than 5×10^6 ESA) that are determined to be structurally adequate for the expected future traffic loadings, as a wearing course restoration treatment.

Surface Preparation

6.29 Defects in the surface to be overlaid must be identified and treated to avoid reflection through into the new overlay. For example, rutting and cracking will typically reflect through thin overlays. The onus is on the pavement designer to identify the extent and severity of defects (e.g. width, concentration and extent of cracking or rutting) and nominate suitable treatments to ensure the design period is achieved.

6.30 Suitable treatments may include the following, including combinations:

a) Crack sealing;

b) Geofabric bandages or full width paving fabric interlayers with bond coat;

c) Asphalt patching;

d) Strain Alleviating Membrane Interlayers (SAMI); and

e) Rutting shape correction with micro surfacing treatment.

The nominated treatments must be clearly identified in the pavement report and drawings.

Treatments for Strengthening Pavements

Heavy Patching (Asphalt)

6.31 Part RD-PV-D1 Table 3-4 Guide to the Selection of Asphalt Types, shall be referred to for the selection of asphalt types, unless otherwise noted here in Part RD-PV-D2.

6.32 The thickness design of heavy asphalt patching (also referred to as “plane and reinstatement”, or “P&R”) of flexible pavements using deflection and curvature data is described in Section 7 of this Supplement.

6.33 The profiled surface must be inspected for defects and suitable treatments adopted, as per the Clauses under Section 6 “Surface Preparation”.

Granular Overlay

6.34 Part RD-PV-D1 Section 6 Unbound Granular Materials, shall be referred to for further information on material availability, standard granular materials, Department material specifications and non-standard granular materials.

6.35 The general Department pavement material types suitable for granular overlays are summarised in Table RD-PV-D2 6-1. 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 RD-PV-D2 6-1 Granular Overlay Material Types

Material Type / Class	Source	Size (mm)	Primary Usage
PM1A*, PM1B*, or PM1† (Class 1)	Quarried	20	Granular Overlay Base Layer
		30	
PM1† (Class 1)	Recycled	20	
		30	
PM2† (Class 2)	Quarried	20	Sealed or Unsealed Shoulders
		30	
		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 the Department's approval.

Macadam

6.36 The existing Department road network includes pavements with layers of coarse gravel to cobble sized particles, which are often referred to as "macadam". A macadam layer typically comprises cobble sized particles at the bottom of the layer, grading finer moving upwards within the layer, with it "blinded off" at the layer surface. The Department has also utilised a 75 mm maximum particle size "crushed rock" as a subbase layer on some roads, which is also sometimes referred to as "macadam".

6.37 Macadam materials are generally not used in modern pavement designs for a number of reasons, including the inability to conduct nuclear density testing on such coarse materials for QA purposes during construction, as well as the cost of the materials and placement. Although road ballast (e.g. RB65) and larger sized materials (e.g. shot rock) may be utilised as select fill in some instances (e.g. soft subgrade treatment).

6.38 Macadam materials can provide a strong, robust and relatively moisture insensitive layer that provides good pavement performance, with moduli greater than conventional crushed rocks. However, they will still eventually deteriorate under trafficking and so must be properly assessed if they are being utilised in the rehabilitation treatment.

6.39 Consideration and utilisation of sound macadam layers treatment design is preferable where viable, as macadam layers can be easily disturbed by profiling when the cut depth is part way through the layer thickness, requiring removal and replacement of the entire layer thickness, at greater cost.

6.40 In this instance, a "chase the base" design strategy, where the depth of profiling targets the top of the macadam base course, may be appropriate. The resulting thickness of asphalt is based upon site investigations such as coring and should be evaluated in CIRCLY to assess the pavement design life and included in the pavement report. The use of asphalt reinforcing grids to mitigate reflection cracking should also be considered. The department does not allow any asphalt thickness reduction from use of grids.

6.41 The use of high binder fatigue resistant bottom layers (AC14HB) can reduce asphalt thickness versus other mixes, potentially avoiding macadam layers and minimising profiling volumes.

In Situ Stabilisation of Granular Pavements

General

6.42 The Guide to Pavement Technology Part 4D: Stabilised Materials (Austroads, 2019) provides guidance on in situ stabilised materials, including the assessment of suitable binders, stabilisation mix design and associated laboratory testing. The Pavement Recycling and Stabilisation Guide (AustStab, 2015) draws upon Part 4D, with additional content on construction methods and quality management. These documents shall be referred to for further guidance on in situ stabilisation of granular pavements.

6.43 If stabilisation is a candidate option for pavement rehabilitation, then the following issues must be considered in further assessing viability and selecting the most appropriate method of stabilisation.

6.44 Existing Pavement Materials:

a) Binder Type - The existing pavement (or subgrade) material properties and the design intent (modified, lightly bound, or fully bound) will determine the appropriate binder type. Austroads 4D (2019) Table 7.6 provides initial guidance on the suitability of different binders related to material particle size distribution and Atterberg limits, with additional binder specific assessment criteria provided later in the guide. Once a candidate binder is selected, the stated mix design process then optimises the binder content to ensure suitable engineering properties are achieved.

b) Aggregate – source material, the strength (hardness, usually measured as Los Angeles Abrasion Value) of the existing pavement material aggregate is an important consideration, as softer materials like calcretes and limestones may break down into smaller particles (mechanical breakdown) during stabilisation processes, with related performance issues and risks.

c) Variability – variations in existing pavement materials and layer thicknesses along a road are a key consideration. Large variations in pavement materials within the stabilisation zone will result in similarly large variations in the stabilised material, potentially rendering the mix design deficient. These variations may arise from variability in the original pavement design and construction, or as a result of subsequent maintenance and rehabilitation works, such as localised granular, asphalt or cement treated patches, or from trench reinstatements, or other causes. The potential for incorporation of subgrades into the stabilised zone must also be considered where marginal existing pavement thicknesses are present. Additional blending and mixing, possibly including additional imported material, may be required to produce a consistent, uniform material suitable for stabilisation, at increased time and cost.

6.45 Asset Life Cycle and Pavement Design:

a) Future maintenance and rehabilitation implications of bound pavement in terms of re-stabilisation or overlay and jointing.

b) Traffic loading and acceptable performance risk.

c) Opportunities for staged construction e.g. using an interim granular overlay for the first 5-10 years of the design period followed by in situ stabilisation to provide satisfactory service over the remainder of the design period.

d) Sensitivity of stabilisation treatment performance to the support provided by the underlying pavement layers and subgrade.

e) Sensitivity of stabilisation treatment performance to variations in depth of stabilisation.

6.46 Construction Issues:

a) The strength and variability of existing subgrade support and the ability to withstand compaction of the stabilised pavement layer shall be assessed by deflection testing or direct measurement.

b) The construction process may limit use of stabilisation in some locations due to environmental impacts, e.g. thicker stabilisation depths may require the use of heavy vibratory rollers, which may induce vibration damage to dwellings in residential areas, or the use of quicklime in this situation could be extremely hazardous to residents.

c) The presence and depth of any rock, public utilities and culverts may restrict stabilisation depths or maximum allowable compactive effort.

d) The presence of deep patches may slow the recycling machine and introduce wet material into the process.

e) Logistics and costs of binder delivery, water, additional quality control requirements to remote locations.

f) Road closure conditions and traffic management constraints will influence the viability of treatments where restricted trafficking during curing is required.

g) Seasonal effects on binders, such as slow setting cementitious binders that require a minimum air temperature of 20ºC to effect hydration.

6.47 In addition, considerations of construction cost and time, and other issues identified in the project scope will influence the viability of stabilisation as a treatment (as they influence consideration of all treatment options).

6.48 It is noted that of the binder types identified in Part 5 and Part 4D, the Department primarily has experience with cement and cementitious blends, lime and foamed bitumen binders, with related Parts in the Department's Master Specification for Roads. Use of other binders may also be feasible, but first-time application on a Department project will require additional risk factors that require careful consideration and mitigation, and is subject to Superintendent approval.

Cement and Cementitious Stabilisation

6.49 Laboratory testing of stabilised materials is undertaken to evaluate the compatibility and suitability of the binder in relation to the parent pavement material. Testing is generally used to characterise the material over a range of selected binders and or binder quantities. A detailed description of binder selection and mix design is presented in Austroads Part 4D (2019).

6.50 To produce a cementitiously bound material suitable for in situ stabilisation of moderate to heavily trafficked roads, the binder content shall be selected such that the minimum Unconfined Compressive Strength (UCS) is 5 MPa at 28 days. Where thin bituminous surfacings are used, a minimum 5% by mass cementitious binder is also required to ensure durability.

6.51 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.

6.52 The achievement of the specified compaction of cemented materials is essential for the development of the modulus and fatigue characteristics adopted in the design. The lower part of the cemented course is particularly critical as this is the zone in which maximum tensile strains occur. The requirement for adequate compaction limits the maximum layer thickness in these materials.

6.53 For single layer construction on heavily trafficked roads the maximum single layer thickness is 360 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.

6.54 Thickness design procedures shall be as described in Section 8.4 of the Guide.

Lime Stabilisation

6.55 Lime stabilisation is typically used for improving clay subgrade soils. It is therefore not a common Department rehabilitation treatment as there are usually a number of practical construction difficulties associated with the removal of the existing pavement materials to access the subgrade for before stabilisation can occur.

6.56 If lime stabilisation of subgrades is an option being considered for widenings or reconstruction, guidance on the thickness design of this treatment is provided in Part RD-PV-D1 "Pavement Design".

6.57 The assessment of the suitability of lime stabilisation of base course material shall use the Guide Table 7.6.

Foamed Bitumen Stabilisation

6.58 Laboratory testing of stabilised materials is undertaken to evaluate the compatibility and suitability of the binder in relation to the parent pavement material. With foamed bitumen stabilisation (FBS), this testing is used to characterise the material at various bitumen and supplementary binder contents, to determine the mix design. Lime shall be used as a secondary binder on Department projects.

6.59 Finely graded gravels, clayey gravels, silty sands (>50% passing 0.425 mm sieve) and other materials that do not achieve significant particle interlock are not included in the definition of bituminous bound materials as their fatigue performance would be variable and unpredictable. Recommended particle size distribution limits are provided in Austroads 4D (2019) Table 5.2.

6.60 A detailed description of binder selection and mix design is presented in Austroads Part 4D (2019). This update delivered improvements in FBS technology and increased harmonisation in investigation, laboratory testing and design procedures, which have been accepted by the Department.

6.61 The Austroads test methods presented in Part 4D Table 5.3 (2019), AGPT/T301, AGPT/T302, AGPT/T303 and AGPT/T305, are to be used for laboratory testing and mix design.

6.62 Thickness design procedures are described in Section 7 of this Supplement.

Design and Construction Considerations

New Pavement Abutting an Existing Pavement

6.63 Construction joints introduce layer discontinuities and zones of structural weakness to the pavement. Section 3 of Part RD-PV-D1 “Pavement Design” provides further guidance on designing joints to minimise the risk of performance issues at joints.

Shoulder Sealing

6.64 Section 3 of Part RD-PV-D1 “Pavement Design” provides guidance on the pavement design of road shoulders.

6.65 For sealing of existing unsealed shoulders, FWD deflection testing may be used to assess whether the shoulder needs strengthening prior to sealing.

Risk, Design Sensitivity, Construction Tolerances and Degree of Control

6.66 In selecting treatments, careful consideration needs to be given to the risks of premature distress of the various options. This is a critical concern for:

a) roads of strategic importance; and

b) roads where there are no alternative routes to divert traffic during lane closures for maintenance (e.g. roundabouts, overpasses, tunnels etc).

6.67 Issues related to the risk of developing premature distress include:

a) Granular overlays

i) Ability to construct the overlay under traffic.

ii) Potential for material to breakdown under repeated reworking and reshaping due to trafficking prior to sealing.

iii) Availability of suitable base materials for the anticipated traffic loading.

iv) The use of primerseals rather than prime and seal when sealing under traffic.

v) Overworking the upper surface in preparation for sealing, creating a slurry of fines and potential seal delamination.

b) Modification of existing granular materials

i) For low dosage cementitious binders, the difficulty in preventing the formation of bound materials with unsatisfactory fatigue performance.

ii) Where chemical binders (other than cementitious or bituminous products) are used to modify granular materials, the performance risks relating to uncertainty in the mix and thickness design procedures are usually higher, with lower homogeneity achieved. Field trials are often required to provide adequate information on treatment performance.

c) Cementitious stabilisation

i) Uniformity of binder spread rates, mixing uniformity (with depth), and deep compaction for single layers in excess of 250 mm thickness. This shall be verified via a trial with density testing.

ii) For multi-lift stabilisation, development of debonding between cemented layers leading to premature failure.

iii) Uncertainty about minimum surfacing requirements to inhibit erosion at construction joints and shrinkage cracks.

iv) For heavily trafficked roads, the rate of distress progression after structural failure and the high cost of remediation.

d) Foamed bitumen stabilisation

i) Uniformity of binder application rates and compaction / density profile of single layers in excess of 250 mm thickness.

ii) Flushing of sprayed seals due to migration of the binder to the surface under trafficking.

7 Thickness Design of Structural Overlays

Introduction

7.1 Chapter 9 of the Guide describes procedures for determining the design thickness of granular overlays placed to correct the structural deficiencies of an existing pavement based upon pavement deflections.

7.2 Editions of the Guide prior to 2019 included similar asphalt overlay thickness design methods based on pavement deflections and curvatures. The Department developed an extension of these methods to determine the design thickness of an asphalt plane and reinstatement treatment (Heavy patching) (Jameson 2005, 2014), as included in this Supplement.

7.3 The 2019 edition of the Guide removed the asphalt overlay design method. However, the Department still endorses use of this method and engaged ARRB to update the design charts in alignment with the current version of AGPT2-17 (Jameson 2019). These updated charts included herein in Section 7 and are to be used with the design of asphalt overlays and asphalt plane and reinstatement treatments.

Flexible Overlays using Design Charts

7.4 The asphalt overlay design method considers both characteristic deflection and characteristic curvature as inputs. In most instances the asphalt overlay thickness from the characteristic curvature greatly exceeds those needed for the characteristic deflection, and will govern the design.

7.5 The deflection and curvature values must be adjusted to account for seasonal moisture variations, measurement temperature and measurement device.

7.6 Characteristics deflection values are calculated as per Section 6.2.6 and 6.2.7 of the 2011 Guide.

7.7 The Department's deflectograph macro calculates the characteristic deflection and curvature, including homogeneous sections, automatically, and these are typically provided to the pavement designer working on Department projects. The macro can also adjust for seasonal moisture, temperature and measurement device if these adjustment factors are input as part of the plot preparation.

Adjustment of Deflections and Curvatures to Account for Seasonal Moisture Variations

7.8 Table 9.2 of the Guide provides moisture correction factors for deflections where better information is not available. Although these factors are broadly consistent with limited monitoring of SA urban sites (Highways Department, 1986), the actual seasonal variations can vary significantly between projects. Hence, wherever possible and particularly for heavily trafficked roads, testing shall be undertaken when the deflections and curvatures are highest, or site-specific factors shall be used.

7.9 If practicable, deflection testing during the dry period between January and April shall be avoided. Local factors can be determined by means of selective retesting of key treatment areas. Alternatively, a common Department approach is to adopt correction factors of between 1.0 and 1.3 unless local conditions clearly indicate that no adjustment is needed.

Adjustment of Deflections and Curvatures to Account for Measurement Temperature

7.10 Appendix C of the 2019 Guide states how to correct Deflections to account for measurement temperature with asphalt pavements. Figures 6.1 and 6.2 of the 2011 Guide (copied below) shall be used for correcting curvatures for measurement temperature, depending on measurement device.

7.11 No correction is needed if the bituminous surfacing is less than 25 mm thick.

Adjustment of Deflections and Curvatures to Account for Measurement Device

7.12 Figure 6.4 of the 2011 Guide (as below) shall be used to standardise deflections and curvatures for measurement device.

Design Periods and Traffic Loading

7.13 The Design Period selected is the time span considered appropriate for the road pavement to function without major rehabilitation or reconstruction.

7.14 Design traffic loadings are calculated using the procedures in Chapter 7 of the Austroads Guide (2017). Additional requirements and considerations stated in the Department's Specification Part RD-PV-D1 also apply to the calculation of design traffic loadings for rehabilitation projects.

7.15 In finalising overlay and patching thickness designs, it is essential that the existing pavement site conditions and distress severity, the past structural performance and maintenance history, and the future loading and environmental influence, be adequately considered. Where the calculated thickness of a structural treatment is inconsistent with past performance the design traffic loading shall be reviewed, including the assumed ESA per heavy vehicle value.

7.16 For wide traffic lanes where significant lateral traffic wander has been observed or is likely, the lower pavement damage resulting from this effect may be taken into account by reducing the lane distribution factor. The minimum lane distribution factor for use in these design traffic calculations is 0.65.

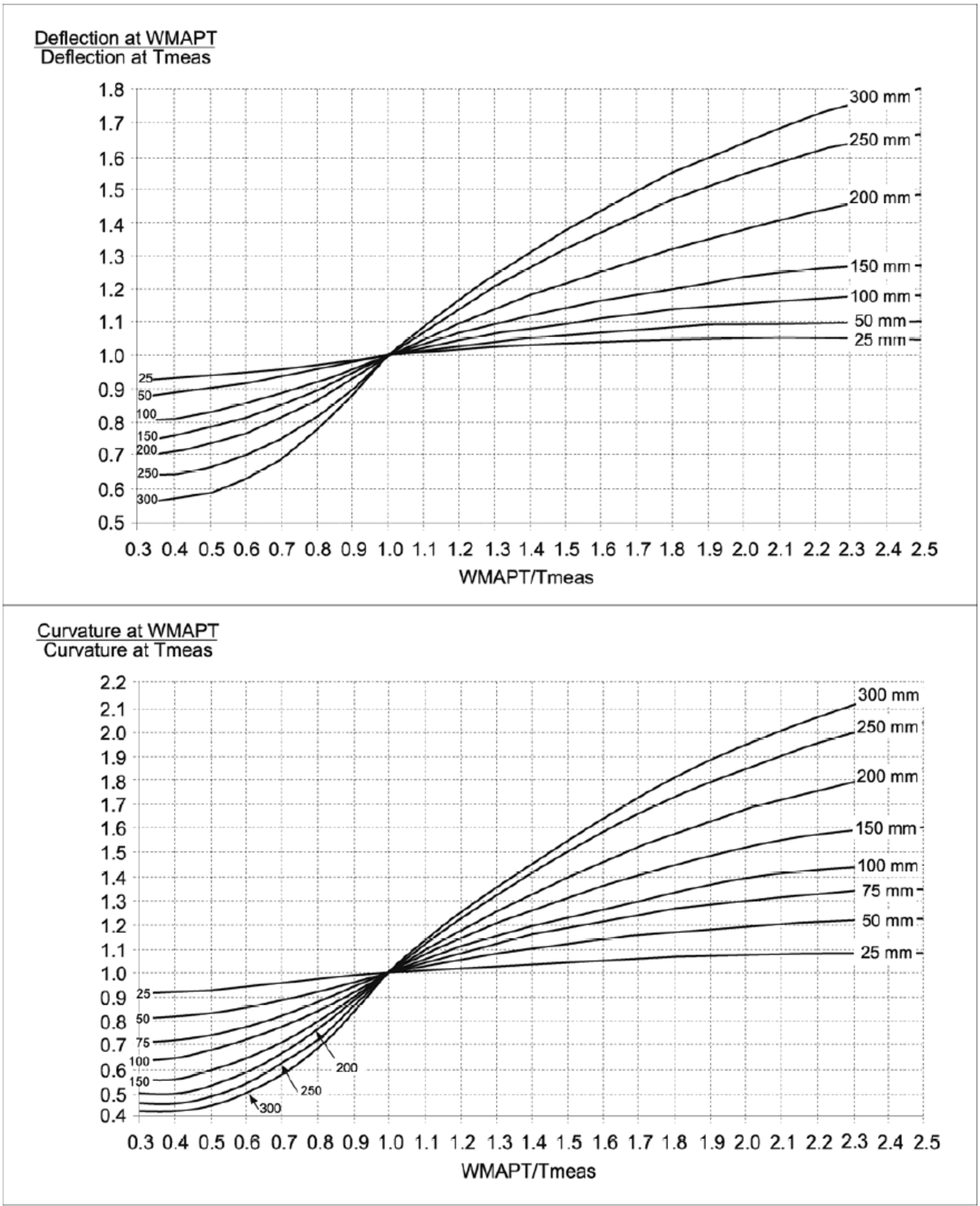


Figure 6.1: Temperature correction of deflectograph and Benkelman Beam deflections and curvatures for various asphalt thicknesses

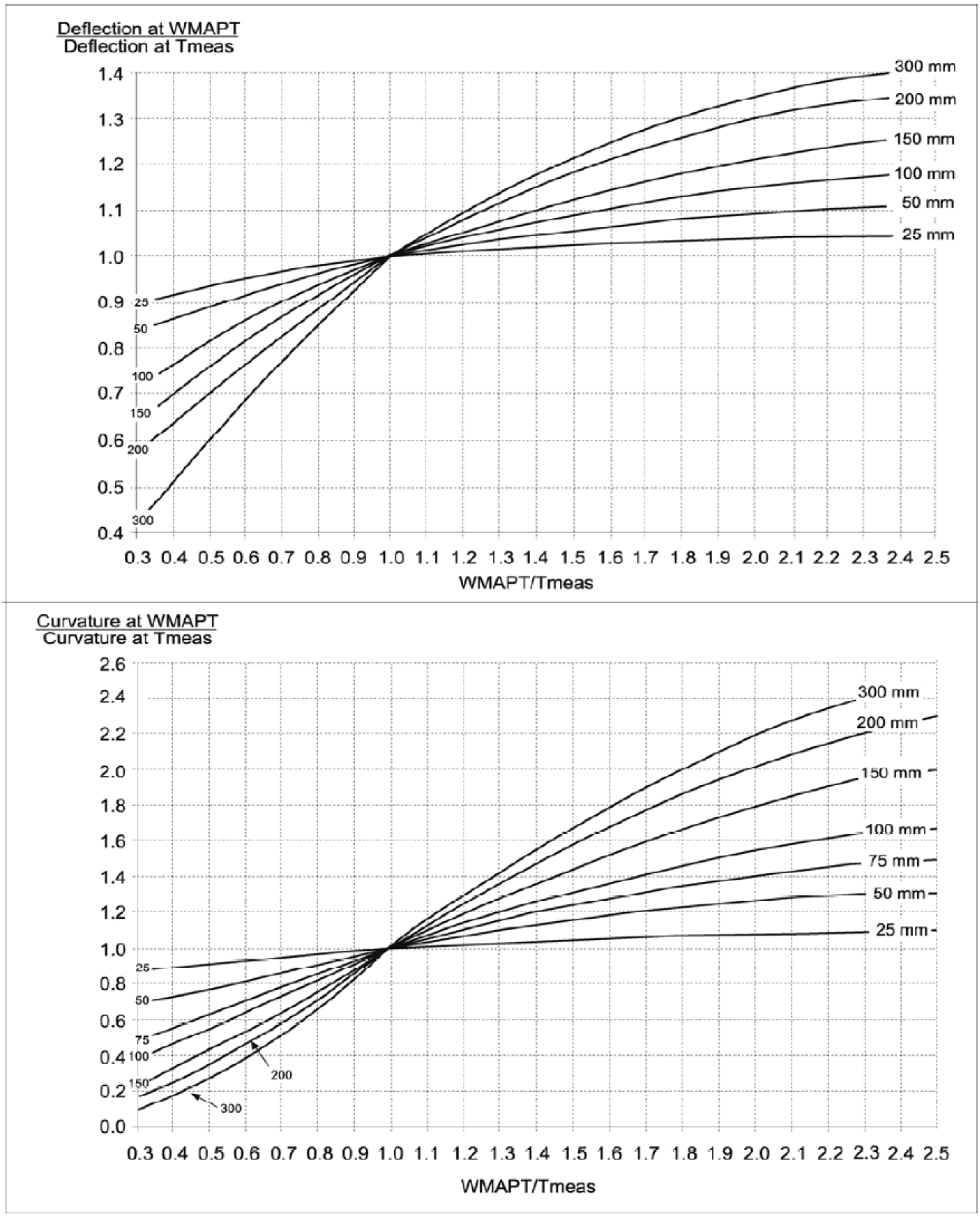


Figure 6.2: Temperature correction of FWD deflections and curvatures for various asphalt thicknesses

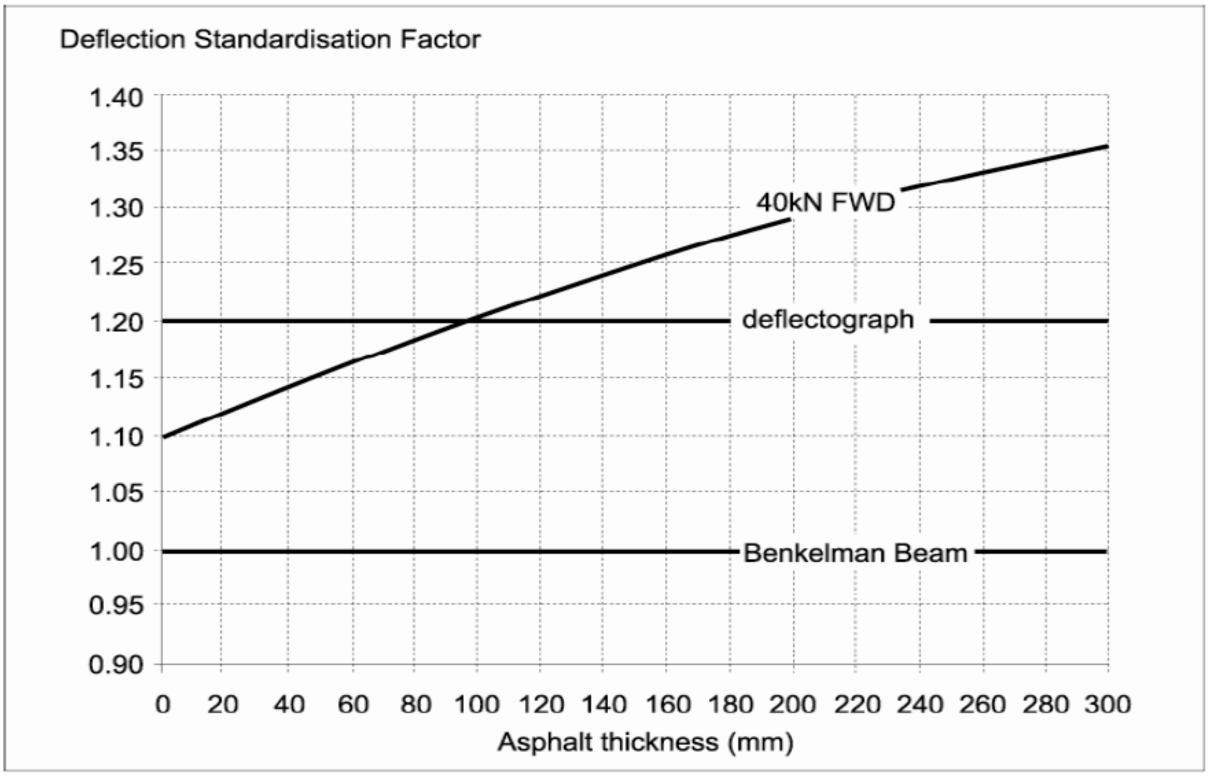


Figure 6.3: Deflection standardisation factors

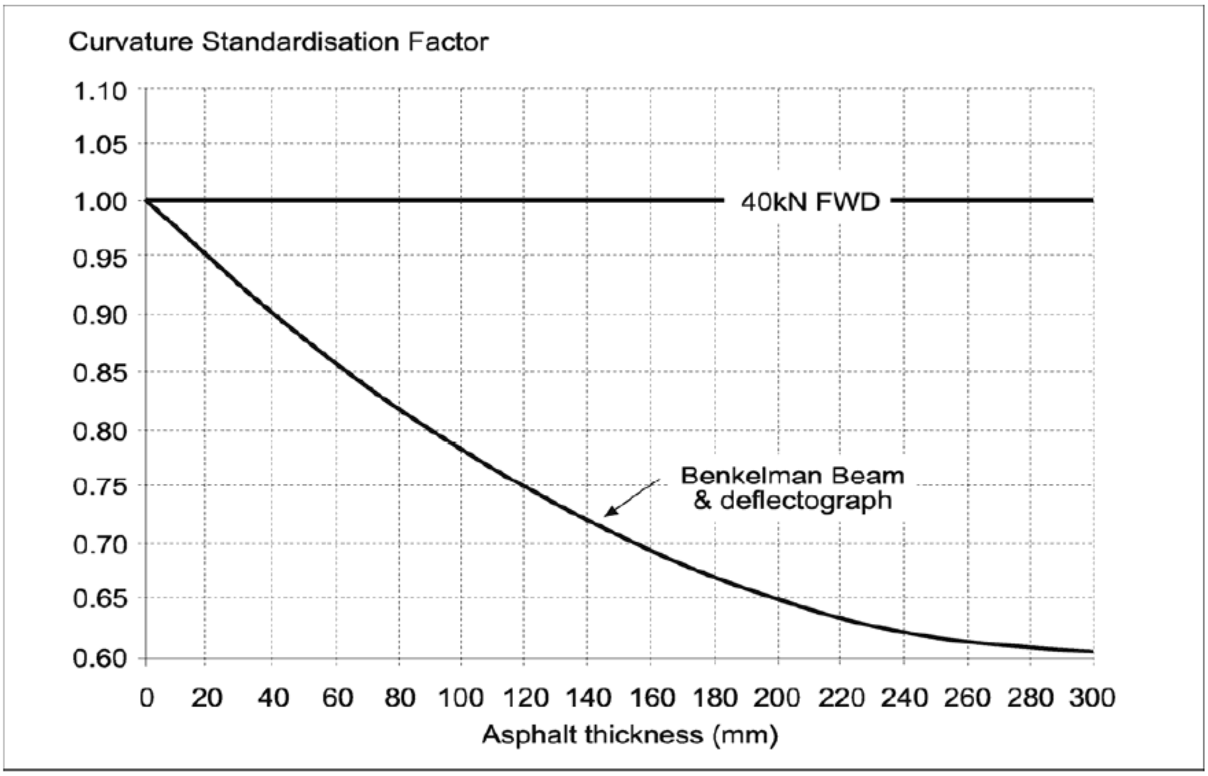


Figure 6.4: Curvature standardisation factors

Fatigue of an Asphalt Overlay

7.17 Figure RD-PV-D2 7-1 and Figure RD-PV-D2 7-2 provide the asphalt overlay thickness required to achieve a particular design traffic loading when constructed on a pavement surface with the selected characteristic curvature. Figure RD-PV-D2 7-1 applies to overlays placed on pavements with an existing asphalt surfacing, while Figure RD-PV-D2 7-2 applies to pavements without an existing asphalt surfacing (e.g. sprayed seal or unsealed). These Figures effectively replace Figure 6.6 in AGPT5-11, accounting for the changes in AGPT2-17 with mechanistic-empirical analyses (Jameson, 2019).

7.18 Asphalt overlay thicknesses obtained from Figure RD-PV-D2 7-1and Figure RD-PV-D2 7-2 shall be rounded up to the next 5 mm value.

Figure RD-PV-D2 7-1 Allowable Traffic Loadings of Asphalt Overlay for Projects with WMAPT of 25-30°C and with Existing Asphalt

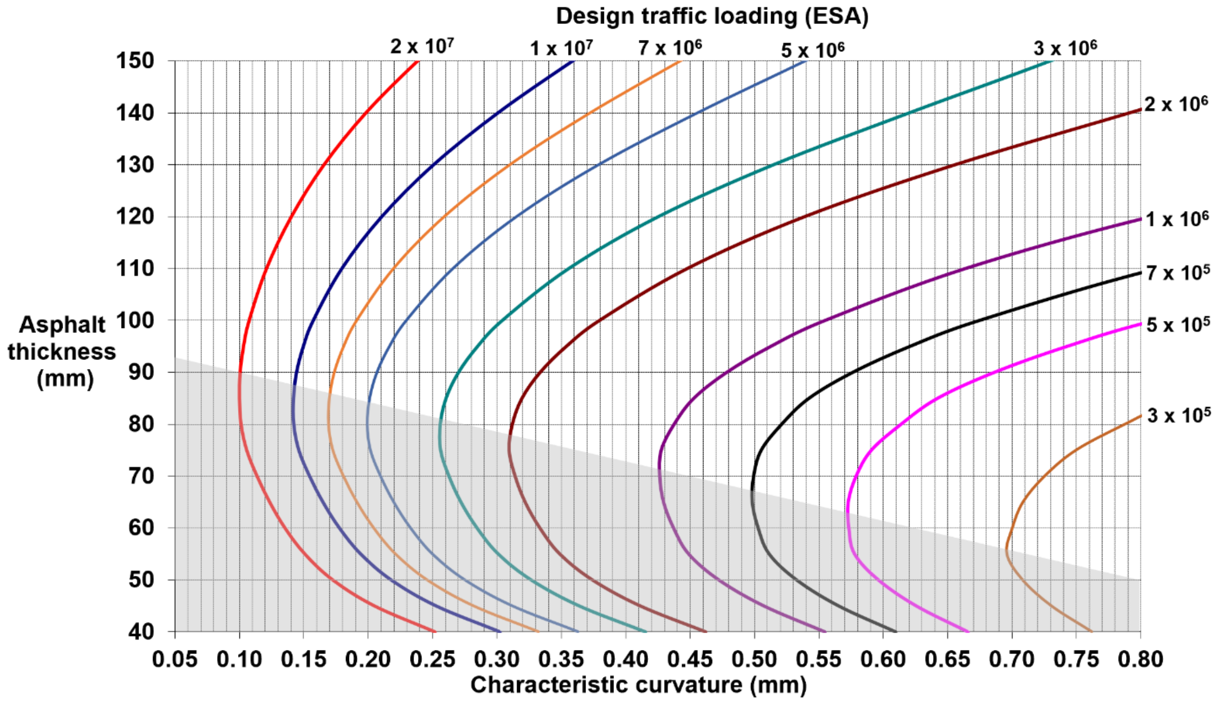
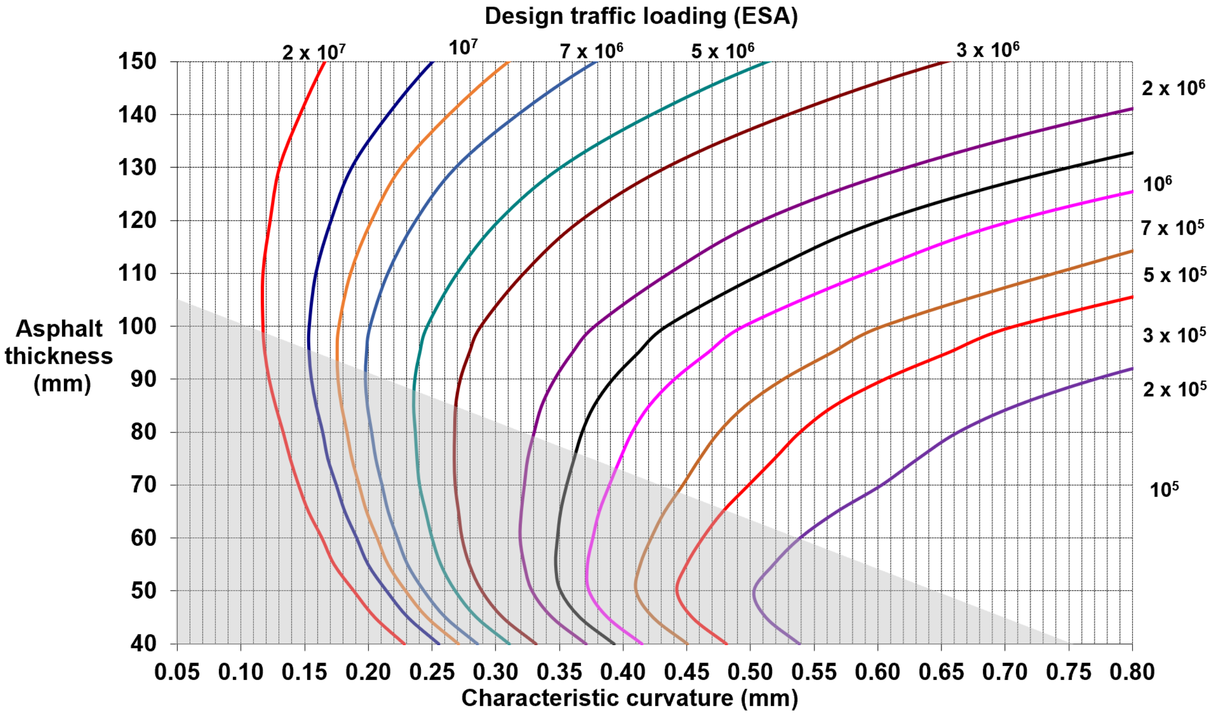


Figure RD-PV-D2 7-2 Allowable Traffic Loadings of Asphalt Overlay for Projects with WMAPT of 25-30°C and without Existing Asphalt



7.19 There is a characteristic curvature below which only a 40 mm overlay thickness is theoretically required to meet fatigue requirements. This characteristic curvature is effectively the left most point of the curves, or the "nose" of the curves. For example, from Figure RD-PV-D2 7-1:

a) 5×10^5 ESA 0.57 mm

b) 2×10^6 ESA 0.31 mm

c) 1×10^7 ESA 0.14 mm

7.20 However, in operation, the performance of thinner overlays is much less reliable because of several factors not well accounted for in the design procedure. The following restrictions on the use of Figure RD-PV-D2 7-1 and Figure RD-PV-D2 7-2 therefore apply:

a) Where the design traffic exceeds 1×10^6 ESA and the characteristic curvature is less than the "nose" curvature value", a 40 mm overlay is an acceptable option provided:

i) the thinner overlay also has adequate fatigue life when the measured characteristic curvature is increased by 20%;

ii) all existing crocodile and other significant cracking is removed via asphalt patching prior to placement of the overlay;

iii) a SAMI is placed under the overlay; and

iv) a modified binder is used in the asphalt overlay mix.

If any of these conditions cannot be met then the asphalt thickness corresponding to the "nose" curvature must be adopted.

b) Where the characteristic curvature is greater than the "nose" curvature value, and in the zone where two overlay thicknesses are output by the method, the greater thickness must be adopted, i.e. the thickness from the upper portion of the curve above the grey shaded area must be adopted.

Department Calculation Spreadsheets

7.21 ARRB has developed several spreadsheets for the Department to assist with undertaking these calculations in an efficient manner:

a) DPTIOlayAConAC 2019.xlsm

b) DPTIOlayAConGR 2019.xls

c) DPTI P&R 2019.xls

7.22 These are available for download on the Department's website under Guidelines – Earthworks and Pavements:

https://www.dit.sa.gov.au/standards/roads-all#earthworksandpavements

Flexible Overlays using General Mechanistic Procedure

Estimation of Pavement Layer and Subgrade Design Moduli

7.23 Back-calculation of the surface deflection bowl data can be used to estimate the elastic modulus of the subgrade and granular materials from software packages such as EFROMD3. However, the errors and uncertainty associated with these back-analysis procedures generally limit their use to the development of indicative pavement models that explain past performance and hence can assist in the design of rehabilitation treatments.

7.24 In most cases it would be inappropriate to use back-calculation as the only means to determine a Design CBR for pavement strengthening treatments. In part, this is because back-calculation does not provide unique modulus solutions and they are more representative of idealistic average values for each assumed layer thickness, rather than the real in situ moduli. Hence supplementary subgrade testing shall be used to validate the back-calculated support conditions and reduce the uncertainty.

7.25 It is also common for the back-calculation process to return only a limited number of useable solutions, which then introduces a bias or further uncertainty about the true characteristic value. Other inaccuracies can result when the actual variability of in situ subgrades are poorly represented by defined sublayer thicknesses.

7.26 In the design of pavement strengthening treatments, the following limitations on design moduli apply:

a) Subgrade vertical design moduli shall not exceed 10 times the laboratory 4-day soaked CBR value to a maximum 100MPa.

b) For unbound granular materials and macadam layers, the design shall be calculated in accordance with Sections 6.2.3 and 8.2.3 of the Austroads Guide (Austroads 2017).

Plane and Reinstatement of Flexible Pavements

P&R Design Using Design Charts

7.27 Plane and reinstatement (P&R) asphalt thickness designs for flexible pavements without cemented materials may be calculated using an approach similar to the design charts developed for asphalt overlay design. The characteristic deflection and curvature values used in overlay design are derived from measurements on the pavement surface. The heavy patching method takes these surficial values and then estimates the increased deflection and curvature values that would be present on the profiled surface following profiling. The reinstatement asphalt thickness on the profiled surface is determined using charts and the estimated profiled surface deflection and curvature, similar to the overlay charts. Table RD-PV-D2 7-1 lists the detailed procedure for calculating the required P&R depth for projects with a WMAPT in the range 25-30ºC.

7.28 This chart-based method is a further development of the mechanistically-derived overlay design method in the Guide. The technical basis was developed by ARRB (Jameson, 2005) and updated again in 2014 (Jameson, 2014). The 2014 update recommended deleting plots for greater than 100 mm of materials, which has been included in this current Supplement (Figure RD-PV-D2 7-3 to Figure RD-PV-D2 7-6). In general terms, the P&R design depths from these charts are expected to provide a similar or reduced performance risk than is associated with other methods previously used by the Department to design these treatments.

7.29 The procedure is only applicable to design traffic loadings in the range 1×10^5 to 2×10^7 ESA. For traffic loadings exceeding 2×10^7 ESA, Mechanistic-empirical Procedures must be used.

7.30 The design charts have a maximum asphalt thickness on the excavated surface of 250 mm. However, if the calculated asphalt thickness exceeds 200 mm, it is recommended that the design thicknesses be confirmed using the Mechanistic-empirical Procedures in view of the assumptions associated with the design charts.

7.31 For projects with a design traffic exceeding 10^6 ESA, the adjustment factors for modified binders in Table 6.4 of the Guide shall not be used for design of strengthening treatments, but may be used to indicate the probable best-case performance.

7.32 A worked example and a P&R thickness design worksheet are provided Appendix A: Examples of Structural Overlay Calculations of this Supplement.

Table RD-PV-D2 7-1 Procedure for Plane and Reinstatement (P&R) Thickness Design

Term	Definition
1	Calculate the design traffic loading in ESA (refer to Chapter 7 of the Austroads Guide (Austroads, 2017)).
2	Using Section 7.4 onwards of this Supplement, calculate the Characteristic Deflection (CD) and the Characteristic Curvature (CC) for each sub-section and required overlay thickness without P&R for permanent deformation (OLAYdef) and for fatigue (OLAYfat).
3	If the required overlay thickness for a sub-section is either excessive compared to adjacent sub-sections or cannot be constructed due to level constraints, identify it as a sub-section for design of a P&R treatment.
4	Select a trial planing depth (PD) for the sub-section. In selecting a trial depth consider whether an overlay (OLAYp) will be placed over the pavement after reinstatement as the structural contribution of the overlay needs to be considered. The trial overlay thickness on the planed surface is then the sum of PD and OLAYp.
5	Calculate the trial thicknesses of existing asphalt and granular materials to be excavated based on the planing depth and the pavement composition.
6	Estimate CC after excavation of the asphalt using Figure RD-PV-D2 7-4. Then adjust the CC for the excavated granular thickness using Figure RD-PV-D2 7-6.
7	Using Figure RD-PV-D2 7-7 and CC after planing (step 6), estimate the allowable traffic loading in terms of asphalt fatigue of the asphalt overlay thickness on the excavated surface.
8	Compare the allowable traffic loading with the design traffic loading (step 1). If the allowable traffic loading is less than the design traffic loading, increase the trial PD for the sub-section and estimate the CC after planing as detailed in step 9 and repeat steps 10. If the allowable traffic loading equals the design traffic loading the trial planing depth and overlay on the reinstated surface is sufficient for asphalt fatigue. If the allowable traffic loading is greater than the design traffic loading, then the asphalt thickness may be reduced. As a check on the calculated thickness the sum of PD and OLAYp shall exceed the overlay thickness without P&R (OLAYfat, step 2).

Figure RD-PV-D2 7-3 Increase in deflection due to removal of asphalt

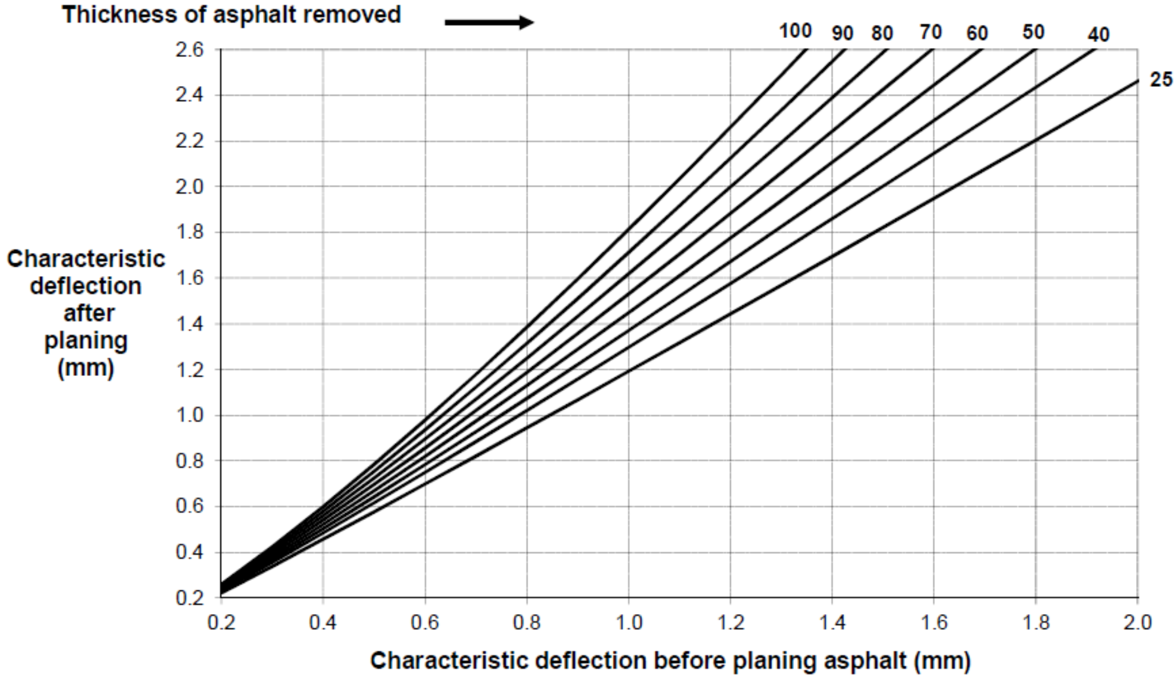


Figure RD-PV-D2 7-4 Increase in curvature due to removal of asphalt

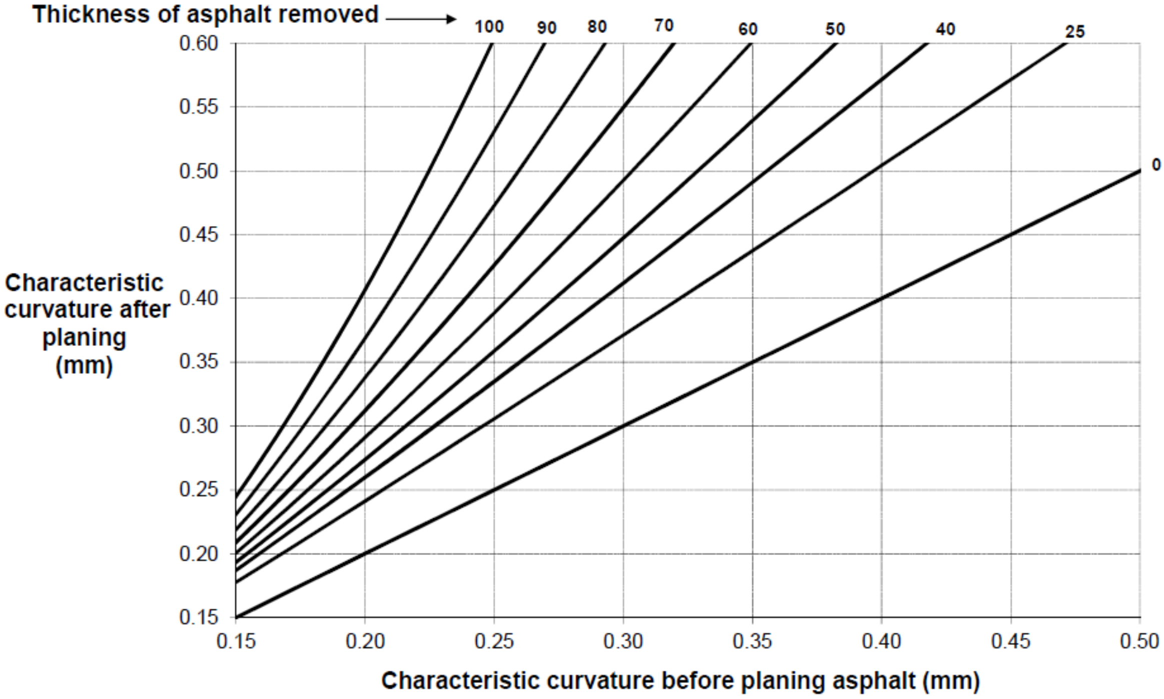


Figure RD-PV-D2 7-5 Increase in deflection due to removal of granular material

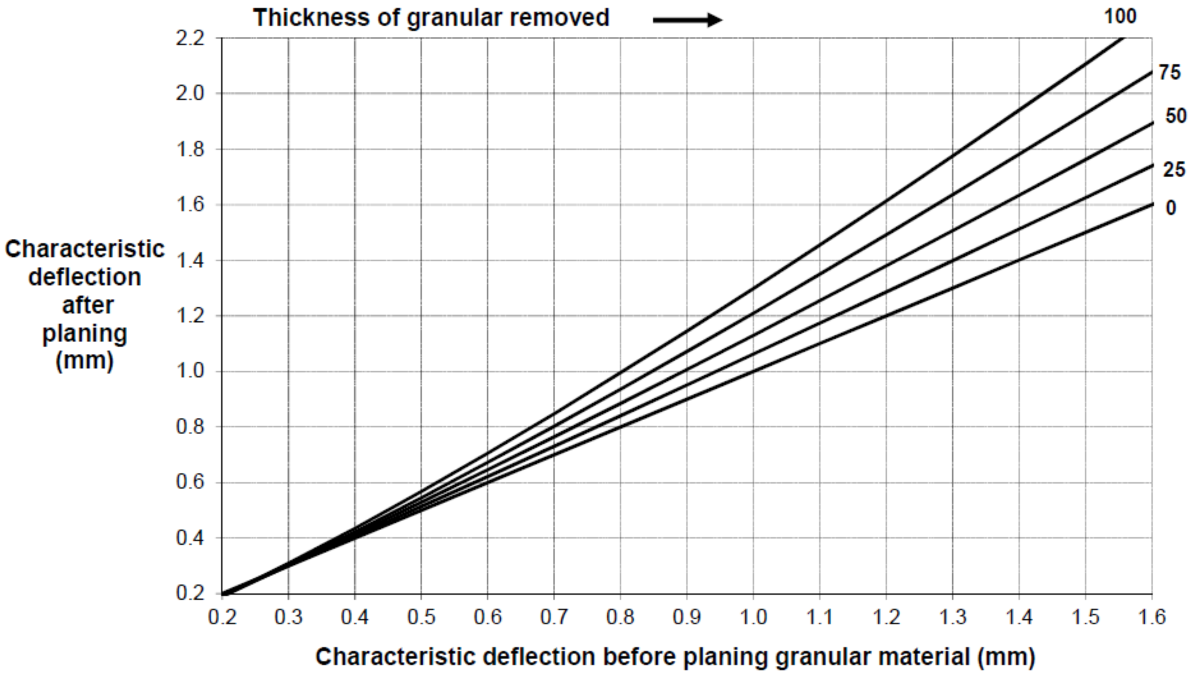


Figure RD-PV-D2 7-6 Increase in curvature due to removal of granular material

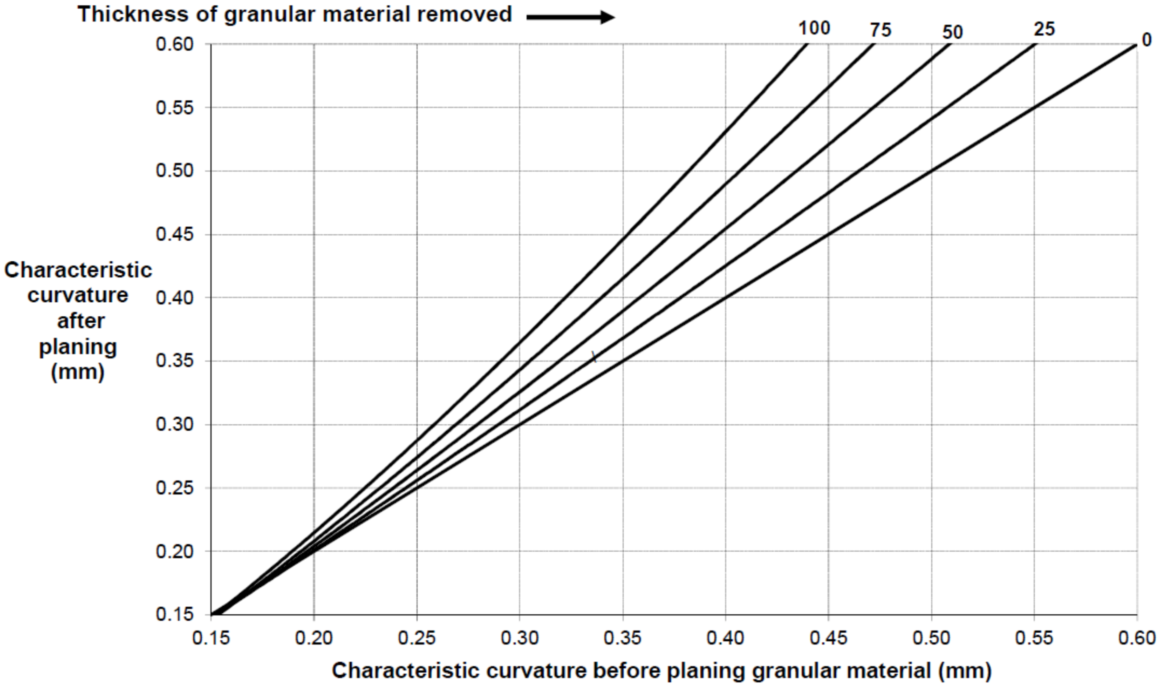
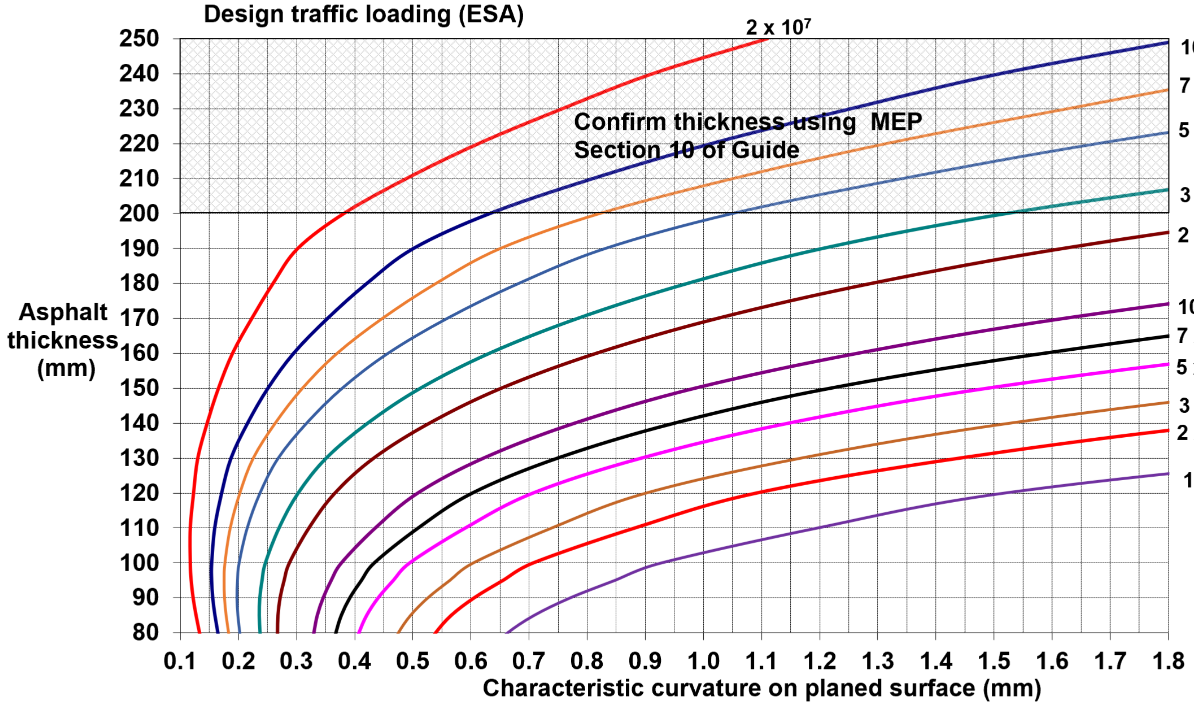


Figure RD-PV-D2 7-7 Asphalt overlay design chart for asphalt fatigue for projects with WMAPT of 25 - 30°C



P&R Design Using General Mechanistic Procedures

7.33 For all flexible pavements, the Mechanistic-empirical Procedures for the design of overlays may be adapted to assess the required plane and reinstatement depth. Having estimated the moduli of the existing pavement materials and subgrade, a trial asphalt reinstatement (mix types, moduli, layer thicknesses) is selected and the layer thicknesses and design moduli of the remaining pavement and subgrade are determined. These layer moduli and thicknesses are used in the linear elastic model CIRCLY. If the allowable loadings exceed the design traffic, the trial P&R depth is acceptable. Otherwise, a new depth is selected and the above analysis steps repeated.

Pavement Layering Considerations

7.34 The selection of pavement material types, layer thicknesses, tolerances, and other details on pavement rehabilitation works must conform to the Department's Part RD-PV-D1.

Pavement Jointing Considerations

7.35 The structural competency of the pavement at longitudinal construction joints is generally not as sound as in other areas. Joints for rehabilitation works must conform with the requirements of the Department's Part RD-PV-D1.

Pavement Widths

7.36 To reduce the effect on pavement performance of vehicles travelling on or near the shoulder, it is common Department practice to extend the pavement 0.5 m beyond the edge line.

7.37 The minimum width of heavy patching is governed by the width of the profiler, which typically varies from 2.3 to 2.5 m. Given a typical lane width is 3 to 3.5 m, two passes of the profiler are necessary to avoid creating a longitudinal joint in the wheel path, such that heavy patching extends the full lane width.

7.38 Narrow patching, such as half lane widths, is acceptable when planing depths are less than 80 mm (preferably about 50 mm) and the paver can straddle the shallow excavation while placing the asphalt reinstatement.

7.39 Unmarked parking areas within wide kerbside lanes are often excluded because of the reduced loadings.

7.40 The minimum practical length of asphalt reinstatement is 5 m. A prime or heavy tack coat shall be applied to all horizontal and vertical faces of the excavation to provide good bonding.

Unsealed Shoulders

7.41 For unsealed shoulders, the minimum total thickness of granular materials is 150 mm for major Rural Arterials and 200 mm for National Highways.

7.42 The uppermost 100 mm or more shall be a Class 2 pavement material or similar with reasonably high plasticity index (6 to 8) to provide low permeability and good surface integrity.

8 Thickness Design of Stabilisation Treatments

Cemented Materials

8.1 The stabilisation depth shall be calculated using the mechanistic-empirical procedures in Section 8 of the Guide (Austroads 2017). A maximum design modulus of 5000 MPa shall be used for materials with a minimum UCS of 5 MPa.

8.2 Multi-layer insitu stabilisation with a cementitious binder may involve performance risks associated with layer debonding, as discussed in Department Part RD-PV-D1. 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.

8.3 For single layer thicknesses in excess of 200 mm, the thickness design needs to allow for the lower compaction likely in the lower portion of the layer. An interim thickness design procedure used by the Department for such situations requires the stabilisation depth to be calculated using a maximum design modulus of 5000 MPa for the top 2/3 of the cemented layer and 2000 MPa for the bottom 1/3 of the layer.

8.4 To achieve adequate compaction and mixing with depth the maximum thickness of a deep-lift layer shall be 360 mm. If the subgrade CBR at the time of construction is less than 5%, a minimum 100 mm unbound granular material shall be retained over the subgrade to improve compaction, and additional material may be needed to meet this requirement. Strengthening can be achieved by placing one or more asphalt layers over the stabilised materials.

8.5 Minimum surfacing treatments on cementitious material shall comply with the Department Part RD-PV-D1 Figure 3-1 for asphalt surfacings. For roads with design traffic loading less than 10^7 ESA, a geotextile reinforced seal can be considered.

Foamed Bitumen Stabilisation

8.6 The minimum single layer thickness of foamed bitumen stabilisation shall not be less than 200mm and to achieve adequate mixing and compaction with depth, the maximum single layer thickness shall not exceed 300 mm. Prior to compaction, the bituminous binder shall be thoroughly mixed in directly after the lime has been introduced, as occurs in the laboratory.

9 Economic Comparison of Alternative Treatments

Introduction

9.1 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. Comprehensive analysis would include economic comparisons of pessimistic, base, and optimistic performance predictions and their associated maintenance costs over the analysis period.

Method for Economic Comparison

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

Economic Parameters

<u>Real Discount Rate</u>

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

Road User Costs

9.4 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:

a) Disruption caused by frequency of maintenance activity.

b) Roughness impacts on the cost of operating vehicles.

c) For strategic routes, implications of damage / disruption due to low probability catastrophic events (e.g. floods, earthquakes), subsidence, expansive subgrade, etc.

d) Traffic noise from particular surfaces.

e) 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.

f) Aesthetic or visual intrusion effects.

g) Traffic and pedestrian safety which may be affected by:

  i) surfacings (texture, colour / visibility etc.); and

  ii) susceptibility of the pavement type to damage (e.g. rutting, cracking, ravelling).

h) Practicality of adopting a different pavement type on a road length which is dominantly of another pavement type.

9.5 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 economical solution may not be the most appropriate.

10 Documentation of Pavement Designs

10.1 Documentation of Pavement Designs shall be as per Part RD-PV-D1 "Documentation of Pavement Designs" with the following additions:

a) Documentation to include:

i) application of deflection based asphalt overlay and granular overlay design methods; and

ii) assessment on the viability of in situ stabilisation.

11 Hold Points

11.1 There are no Hold Points referenced in this Part.

12 References

a) Austroads (2018). AP-T336-18 Design and Performance of Foamed Bitumen Stabilised Pavements. Austroads, Sydney.

b) Austroads (2017). Guide to Pavement Technology Part 2 Pavement Structural Design. Austroads, Sydney.

c) Austroads (2013). AP-T236-1 Update of Double/Double Design for Austroads Sprayed Seal Design Method. Austroads, Sydney.

d) Austroads (2019). Guide to Pavement Technology Part 5 Pavement Evaluation and Treatment Design. Austroads, Sydney.

e) Austroads (2009a). Guide to Pavement Technology Part 3 Pavement Surfacings. Austroads, Sydney.

f) Austroads (2019). Guide to Pavement Technology Part 4D: Stabilised Materials. Austroads, Sydney.

g) Austroads (2017). Guide to Pavement Technology Part 4F Bituminous Binders. Austroads, Sydney.

h) Austroads (2018). Guide to Pavement Technology Part 4K Seals. Austroads, Sydney.

i) Austroads (2018). Guide to Asset Management – Technical Information Part 15: Technical Supplements. Austroads, Sydney.

j) Austroads (2005). Guidelines for the Management of Road Surface Skid Resistance. Pub. No. AP-G17/04 Austroads, Sydney.

k) AustStab (2015). Pavement Recycling and Stabilisation Guide – Second Edition. AustStab Ltd, Cherry Brook, New South Wales.

l) Clegg (1980). An Impact Soil Tester as an Alternative to California Bearing Ratio. Proc. 3rd ANZ Geomechanics Conference, 1, pp 225-230.

m) DPTI (2016) Road Surface Friction (Skid Resistance & Pavement Texture) Recommended Investigatory Levels, Tech Note 24. DPTI Technical Services Group.

n) DPTI (2011). Guide to Bikeway Pavement Design Construction & Maintenance for South Australia. Safety and Service Division.

o) Highways Department (1986). Seasonal Variations in Pavement Deflection. Report MS 31-1.

p) Jameson G W (2005). Plane and Reinstate Thickness Design. ARRB Group Report VE71073-2 for Transport Services Division, DTEI.

q) Jameson G W (2014). Selection and Design of Pavement Treatments for Metropolitan Region. ARRB Group Report 008711-1 for Department of Planning, Transport and Infrastructure.

r) Jameson G W (2019). Asphalt Overlay and Inlay Design Charts. ARRB Report Project No. 015180 for Department of Planning, Transport and Infrastructure.

s) Little, D.N (1995). Handbook for Stabilisation of Pavement Subgrades and Base Courses with Lime. (Kendall/Hunt).

t) Queensland Transport (1988). Applications for the Clegg Impact Soil Tester. Technical Note 5 (QDMR: Brisbane).

u) Robinson, P., Oppy, T., Giummarra, G. (1999). Pavement Materials in Road Building: Guidelines for Making Better use of Local Materials. ARRB TR.

v) van Loon, H. (2014). Seasonal Variation in Skid Resistance of South Australian Aggregates. Department of Planning, Transport and Infrastructure. 26th ARRB Conference, Sydney, New South Wales 2014.

13 Appendix A: Examples of Structural Overlay Calculations

A.1 Example of Plane and Reinstatement Thickness Design

This design example illustrates the method of calculating the required depth to which to plane pavements prior to reinstatement with asphalt. The required plane and reinstate (P&R) depth is the greater of the depth to inhibit permanent deformation and to inhibit fatigue of the asphalt patching material.

A homogeneous section of a cracked asphalt surfaced granular pavement is situated in a locality where the WMAPT, from Appendix B of Austroads (2019), is 27°C. The existing asphalt is 50 mm thick.

The following characteristic values were calculated from deflectograph deflection testing undertaken at a pavement temperature of 24°C:

- measured characteristic deflection at 24°C = 1.1 mm
- measured characteristic curvature at 24°C = 0.36 mm

Based on experience, the designer considered that there was no need to apply a Seasonal Moisture Correction Factor to these measured deflections and curvatures.

The design traffic loading for the section was 5×10^6 ESA.

Using the Austroads (2011) overlay design method with Figure RD-PV-D2 7-1, an asphalt overlay thickness in excess of 100 mm is required. As level constraints prohibited this increase in surface level, the proposed rehabilitation strategy is to P&R this traffic lane and then place a 40 mm overlay the full carriageway width.

M&R Thickness Required for Permanent Deformation
Design deflection (from Figure 9.2 of Austroads (2019)) = 0.94 mm.

Temperature factor = WMAPT/T measured = 27/24 = 1.12

From Figure C.1 of Austroads (2019) – see Section 7 of this Supplement – for 50 mm existing asphalt thickness the deflection adjustment factor = 1.01, therefore the temperature adjusted characteristic deflection = 1.1 × 1.01 = 1.11 mm.

From Table 9.2 of Austroads (2019) – see Section 7 of this Supplement – a deflection standardisation factor for deflectograph maximum deflections is 1.2. Therefore, the adjusted characteristic deflection is 1.11 x 1.2 = 1.34.

To provide guidance on the required planing depth, the overlay required without P&R is first calculated. From Figure 6.9 of Austroads (2011), for a design traffic of 5×10^6 ESA and CD of 1.34 mm, the required overlay without P&R is 50 mm. Therefore, the dense graded asphalt overlay required without patching is 50 mm. Hence the P&R depth is expected to exceed 50 mm as the planing will remove some or all the existing asphalt.

The next step is to select a trial P&R depth. The following treatment was selected after several trials: excavated the existing pavement to a depth of 80 mm, thus removing 50 mm of asphalt and 30 mm of granular material.

Using Figure RD-PV-D2 7-3 of this Supplement, after removing the 50 mm asphalt surfacing the CD increases from 1.34 mm to 1.9 mm.

Using Figure RD-PV-D2 7-5 of this Supplement, after removing 30 mm of granular material the CD increases from 1.9 mm to 2.15 mm.

From Figure RD-PV-D2 7-7 of this Supplement, for a CD of 2.15 mm on the excavated surface and a design traffic of 5×10^6 ESA, a 112 mm overlay is required on the excavated surface to inhibit permanent deformation at a WMAPT of 27°C. From Table 10.4 of Austroads (2019) for a WMAPT of 27°C, the required thickness of dense graded asphalt (Class 320 binder) is 112 x 1.0 = 112 mm.

Hence a 120 mm asphalt thickness is required on the excavated surface for permanent deformation, comprising patching to 80 mm followed by a 40 mm overlay.

M&R Thickness Required for Asphalt Fatigue
Temperature factor = WMAPT/T measured = 27/24 = 1.12

From Figure 6.1 of Austroads (2011) – see Section 7 of this Supplement – the curvature adjustment factor for 50 mm existing asphalt thickness is = 1.03

Temperature adjusted characteristic curvature = 0.36 × 1.03 = 0.37 mm.

From Figure 6.4 of Austroads (2011), see Section 7 of this Supplement, the curvature standardisation factor for deflectograph curvatures measured on a pavement with 50 mm asphalt thickness is 0.88. Therefore, the adjusted characteristic curvature (CC) is 0.37 mm x 0.88 = 0.33 mm.

From Figure RD-PV-D2 7-1, for a design traffic of 5 x 10^6 ESA and a CC of 0.33 mm, the required asphalt overlay without P&R is 125 mm.

Hence the required asphalt thickness after planing needs to equal or exceed 125 mm thickness. It was decided to trial a P&R depth of 150 mm.

Using Figure RD-PV-D2 7-4 of this Supplement, after removing the 50 mm asphalt surfacing the CC increases from 0.33 to 0.51 mm. Then, using Figure RD-PV-D2 7-6 of this Supplement, after removing 100 mm of granular material the CC increases from 0.51 mm to 0.81 mm.

From Figure RD-PV-D2 7-7 of this Supplement, for a CC of 0.81 mm on the excavated surface and a design traffic of 5 x 10^6 ESA, a 190 mm asphalt thickness is required on the excavated surface to inhibit asphalt fatigue.

This trial P&R depth is acceptable as the required 190 mm asphalt overlay on the excavated surface matches the total of the planing depth of 150 mm plus a 40 mm increase in surface levels which is acceptable.

The required P&R depth is the maximum of that required for permanent deformation (80 mm) and that required for fatigue of the patching material (150 mm).

Hence it was concluded that the following strengthening treatment would be suitable for the project:

- plane 50 mm asphalt and 100 mm granular material from the pavement
- patch the excavation by placing 150 mm thickness of asphalt in two layers
- apply a 40 mm overlay over all traffic lanes.

The design calculations are given in Table RD-PV-D2 13-1.

Table RD-PV-D2 13-1 Example of plane and reinstate thickness design calculations PLANE AND REINSTATE THICKNESS DESIGN

Project: **Appendix C design example**	Design Date: **30 October 2019**
Design traffic loading	**5 x 10^6** ESA
Deflection measurement device	**Deflectograph**
Weighted Mean Annual Pavement Temperature	**27** °C
Existing asphalt thickness (if any)	**50** mm
Temperature of existing AC during deflection testing (Tmeas)	**24** °C
WMAPT/T_{meas} (for existing AC)	**27/24 = 1.12**

P & R thickness required for permanent deformation		
Measured characteristic deflection		**1.1** mm
Seasonal moisture correction factor (Table 9.1, Austroads 2019)		**1.0**
Deflection adjustment factor for temperature (Figure C.1, Austroads 2019)		**1.02**
Deflection standardisation factor for measurement device (Table 9.2, Austroads 2019)		**1.2**
Adjusted characteristic deflection	**...1.1… × …1.0… × …1.02… × …1.2… =**	**1.34** mm
Asphalt overlay required for permanent deformation, OLAYdef, (i.e. without P&R), Figures 6.9 and 6.10 (Austroads 2011)	**50 x 1.08 =**	**55** mm
Trial planing depth (PD)		**80** mm
Trial thickness of asphalt excavated		**50** mm
Trial thickness of granular excavated		**30** mm
Overlay thickness on reinstated surface (OLAYp), if any		**40** mm
Characteristic deflection after excavation of asphalt (Figure RD-PV-D2 7-3)		**1.9** mm
Characteristic deflection after excavation of granular (Figure RD-PV-D2 7-5)		**2.15** mm
Required asphalt thickness on excavated surface at 25 °C (Figure RD-PV-D2 7-7)		**112** mm
Overlay adjustment factor (Table 10.4, Austroads 2019)		**1.08**
Required asphalt thickness on excavated surface at WMAPT	**112 × 1.0 =**	**112** mm
Check that required asphalt thickness equals the sum of PD + OLAYp =	**80 + 40 =**	**120** mm

P&R thickness required for asphalt fatigue		
Measured characteristic curvature:		**0.36** mm
Seasonal moisture correction factor (Table 9.1, Austroads 2019)		**1.0**
Curvature adjustment factor for temperature (Figure C.1 or C.2, Austroads 2019)		**1.03**
Trial planing depth (MD)		**150** mm
Trial thickness of asphalt excavated		**50** mm
Trial thickness of granular excavated		**100** mm
Existing asphalt thickness after planing		**0** mm
Curvature standardisation factor for measurement device (Figure 6.4, Austroads 2011)		**0.88**
Adjusted characteristic curvature	**0.36… × ...1.0… × ...1.03… × …0.88… =**	**0.33** mm
Overlay thickness on reinstated surface (OLAYp), if any		**40** mm
Characteristic curvature after excavation of asphalt (Figure RD-PV-D2 7-4)		**0.51** mm
Characteristic curvature after excavation of granular (Figure RD-PV-D2 7-6)		**0.81** mm
Required asphalt thickness on excavated surface (Figure RD-PV-D2 7-7)		**190** mm
Check that required asphalt thickness equals the sum of MD + OLAYp =	**150 + 40 =**	**190** mm

Summary	
P&R depth required for permanent deformation	**= 80 mm**
P&R depth required for asphalt fatigue	**= 150 mm**
Overlay (if any) proposed on reinstated surface	**= 40 mm**

Plane and Reinstatement Thickness Design Worksheet

PLANE AND REINSTATEMENT THICKNESS DESIGN	
Project:	Design Date:
Design Traffic Loading	ESA
Deflection Measurement Device	
Weighted Mean Annual Pavement Temperature (WMAPT, 2019 AGPT5 Appendix B) °C	
Existing Asphalt Thickness (if any)	mm
Temperature of existing AC during deflection testing (Tmeas)	°C
WMAPT/Tmeas (for existing AC)	
P&R thickness required for asphalt fatigue	
Measured Characteristic Curvature:	mm
Seasonal Moisture Correction Factor (Table 9.2 2011 AGTP5 Guide)	
Curvature Adjustment Factor for Temperature (2011 AGPT5 Figure 6.1 or 6.2**)	
Curvature Standardisation Factor for Measurement Device (2011 AGPT5 Figure 6.3)	
Adjusted Characteristic Curvature	.... × .... × .... × .... = mm
Asphalt overlay required for fatigue, OLAYfat, (i.e. without M&R), Figure RD-PV-D2 7-5 or Figure RD-PV-D2 7-6	mm
Trial planing depth (PD)	mm
Trial thickness of asphalt excavated	mm
Trial thickness of granular excavated	mm
Overlay thickness on reinstated surface (OLAYp), if any	mm
Characteristic Curvature after excavation of asphalt (Figure RD-PV-D2 7-4)	mm
Characteristic Curvature after excavation of granular (Figure RD-PV-D2 7-6)	mm
Required asphalt thickness on excavated surface for WMAPTs of 25-30°C (Figure RD-PV-D2 7-7)	mm
Check required asphalt thickness equals the sum of PD + OLAYp	.... + ... = mm
Summary	
P&R depth required for permanent deformation	**= mm**
P&R depth required for asphalt fatigue	**= mm**
Overlay (if any) proposed on reinstated surface	**= mm**

Notes:
**Figures 6.1, 6.2 and 6.3 of the 2011 edition of AGPT5 were removed in the 2019 edition, but they are reproduced on page 27, 28 and 29 of RD-PV-D2.