0042 PAVEMENT DESIGN

1 GENERAL

1.1 RESPONSIBILITIES

Objective
General: Select appropriate pavement and surfacing materials, types, layer thicknesses and configurations to ensure that the pavement performs to its design functions and requires minimal maintenance under the anticipated traffic loading for the design life adopted.

Criteria: This worksection covers the design of road pavement to meet the required design life, based on the subgrade strength, traffic loading, climatic conditions, environmental factors, and includes the selection of appropriate materials for subgrade, subbase, base and wearing surface.

1.2 CROSS REFERENCES

General
Requirement: Conform to the following worksection(s):
- 0010 Quality requirements for design.
- 0043 Subsurface drainage (Design).
- 1131 Rolled concrete subbase.
- 1132 Lean mix concrete subbase.
- 1133 Plain or reinforced concrete base.
- 1134 Steel fibre reinforced concrete base.
- 1135 Continuously reinforced concrete base.
- 1141 Flexible pavement base and subbase.
- 1143 Sprayed bituminous surfacing.
- 1144 Asphaltic concrete (Roadways).
- 1145 Segmental paving.
- 1146 Bituminous slurry surfacing.

Related worksections: The following worksection is related to this worksection:
- 0041 Geometric road layout.

1.3 REFERENCED DOCUMENTS

Standards
General: The following documents are incorporated into this worksection by reference:

Austroads
AGPT04C:2009 Guide to Pavement Technology – Part 4C Materials for Concrete Road Pavements.
AGRD08:2009 Guide to Road Design - Part 8 Process and Documentation
AP-T68:2006 Update of the Austroads sprayed seal design method.

Other publications
Cement Concrete Aggregates Australia (CCAA)
Concrete Masonry Association of Australia (CMAA)
1.4 STANDARDS

General
Standard: Road design to Austroads AGRD01 and AGRD02.
Design considerations: To AGRD02 Table 3.1.
Pavement structural design: To AGPT02.

2 DESIGN CRITERIA

2.1 PAVEMENT

General
Pavement types: To AGPT01.

Design variables
All proposed road pavements: Consider the following input variables for Urban and rural roads:
- Design traffic.
- Subgrade evaluation.
- Climatic conditions (For climatic zones see www.bom.gov.au).
- Environment – surface noise considerations (To AGPT02 Section 4).
- Pavement and surfacing materials – note any exclusions of local aggregates commonly available.
- Construction and maintenance considerations (To AGPT02 Section 3).
The design variables may be different in different states. Refer to the relevant design manuals of State Road Authorities for more information www.australia.gov.au.

2.2 TRAFFIC

Standards
General: To AGPT02 Section 7 and Section 12.

Minimum pavement design life
General: Select the design life to suit the design traffic conditions based on the following minimum design lives of pavement. Alternatively calculate the ‘whole of life’ costs and adopt an appropriate ‘first cost’ to select the pavement:
- Flexible, unbound granular: 25 years.
- Flexible, containing one or more bound layers: 25 years.
- Rigid (concrete): 40 years.
- Segmental block: 25 years.

Equivalent standard axles (ESA)
General: Calculate design traffic in equivalent standard axles (ESAs) for the applicable design life of the pavement, taking into account present and predicted commercial traffic volumes, axle loadings and configurations, commercial traffic growth and street capacity. AGPT02 Table 7.4 provides the values of cumulative growth factor for a range of annual growth rates and design period.

Interlocking concrete segmental pavements: The simplification of replacing ESA’s with the number of commercial vehicles exceeding 3 tonne gross contained in CMAA—T45 is acceptable up to a design traffic of 10^6. Beyond this, calculate ESAs.

Traffic data
Pavement design: Include all traffic data and/or assumptions made in the calculation of the design traffic. Consider the width of structural pavement beyond the trafficked lanes to suit edge conditions and traffic movements.

Design traffic volumes
Calculation of design traffic volumes for lightly trafficked roads: To AGPT02 Section 12.
Calculation of design traffic volumes approaching or exceeding $10^6$ ESAs: To AGPT02 Section 12.7.

**Guide to design ESAs**

Traffic values (in ESAs): To AGPT02 Table 12.2 for lightly trafficked urban streets and to **Design ESA’s 25 year design life table** subject to variation depending on the circumstances for the particular project.

**Design ESA’s 25 year design life table**

<table>
<thead>
<tr>
<th>Street type</th>
<th>Design ESA’s—25 year design life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Residential</td>
<td></td>
</tr>
<tr>
<td>- Access Street</td>
<td>$6 \times 10^4$</td>
</tr>
<tr>
<td>- Local Street</td>
<td>$3 \times 10^5$</td>
</tr>
<tr>
<td>- Collector Street</td>
<td>$1 \times 10^6$</td>
</tr>
<tr>
<td>Local Sub-Arterial</td>
<td>$2 \times 10^6$</td>
</tr>
<tr>
<td>Rural Residential</td>
<td>$3 \times 10^5$</td>
</tr>
<tr>
<td>Commercial and Industrial</td>
<td>$5 \times 10^6$</td>
</tr>
</tbody>
</table>

### 2.3 SUBGRADE EVALUATION

**Design considerations**

- Sequence of earthworks construction.
- The compaction moisture content and field density specified for construction.
- Moisture changes during service life.
- Susceptibility to flooding.
- Subgrade variability.
- The presence or otherwise of weak layers below the design subgrade level.
- Stabilisation requirements.
- Dispersive soils.
- Plasticity parameters.
- Swell characteristics.
- Salinity.

**California Bearing Ratio (CBR)**

Except where a mechanistic design approach is employed using AGPT02 (or software designed for this purpose), as the measure of subgrade support, use the California Bearing Ratio (CBR).

Where a mechanistic design approach using linear elastic theory is employed for flexible pavements, the measure of subgrade support is in terms of the elastic parameters (modulus, Poisson’s ratio).

**Design CBR considerations**

Adopted subgrade Design CBR: Consider the effect of moisture changes in the pavement and subgrade during the service life involving the following:

- Provision of subsurface drainage in the estimation of equilibrium in-situ CBRs.
- Design of the pavement structure.

Subsurface drainage: Refer to **0043 Subsurface drainage (Design)**. If subsurface drainage is not proposed, the Design CBR must allow for a greater variability in subgrade moisture content during the service life of the pavement with a design moisture content above the optimum moisture content.

**Calculation of design CBR**

Criteria: Conform to the following:

- Field determination of subgrade CBR (To AGPT02 Section 5.5)
  - In situ CBR test.
  - Cone penetrometers.
- Laboratory determination of CBR and elastic parameters (To AGPT02 Section 5.6)
- Presumptive values for lightly trafficked roads. (To AGPT02 Section 5.7, Table 5.4)
Field confirmation
Testing: Confirm the Design CBR obtained from laboratory testing by site testing performed on existing road pavements near to the job site under equivalent conditions and displaying similar subgrades. Consider the use of dynamic cone penetrometer (DCP) in test pits within the subgrade for use in conjunction with CBR testing.

Summary of results
Pavement design: Include a summary of all laboratory and field test results and assumptions and/or calculations made in the assessment of Design CBR.

2.4 ENVIRONMENT

Environmental factors
Pavement design: Include all considerations for environmental factors, and any assumptions made that would reduce or increase design subgrade strength, or affect the choice of pavement and surfacing materials.

Moisture and temperature
General: Consider moisture and temperature at the design stage of the pavement. Refer to AGPT02 Section 4.

Moisture considerations
Significant factors: Consider the following factors relating to moisture environment in determining the design subgrade strength/stiffness and in the choice of pavement and surfacing materials:
- Rainfall/evaporation pattern.
- Permeability of wearing surface.
- Depth of water table and salinity problems.
- Relative permeability of pavement layers.
- Whether shoulders are sealed or not.
- Pavilion type (boxed or full width).

Design moisture content
Changes in moisture content: Evaluate the design subgrade strength parameters (i.e., CBR or modulus) at the highest moisture content likely to occur during the design life, i.e., the design moisture content.

Temperature changes
Asphalt wearing surfaces and bound or concrete layers: Consider the effect of maximum/minimum seasonal variations in temperature in the design of pavements, particularly if traffic loading occurs at night when temperatures are low and cause a potential reduction in the fatigue life of thin asphalt surfacing.

Specific location effects
In selection of pavement, consider the following:
- Freezing.
- Snow/ice removal (use of chemicals/salt).
- Mine subsidence.
- Bushfire heat.
- Extreme temperatures.
- Industrial traffic spills.

Pavement evaluation and treatment design:
- Conform with AGPT05 for investigation of existing sealed road pavements and design of pavement treatment.

2.5 PAVEMENT AND SURFACING MATERIALS

Pavement classification
Pavement materials: Adopted classification according to their fundamental behaviour under the effects of applied loadings:
- Unbound granular materials, including modified granular materials.
- Bound (cemented) granular materials.
- Asphaltic Concrete.
- Cement Concrete.

Conform to the following:
- To AGPT04C for concrete road pavements.
- To AGPT06 for unsealed pavements.

**Surfacing classification**
Surfacing materials: Adopted classification:
- Sprayed bituminous seals (flush seals).
- Asphaltic concrete and bituminous slurry surfacing (cold overlay).
- Cement concrete.
- Concrete segmental pavers.
- Clay segmental pavers.

**Materials**
Pavement materials: To AGPT02 Table 6.1 for pavement material categories and characteristics.
Unbound granular materials including modified granular materials: To 1141 Flexible pavements.
Bound (cemented) granular materials: To 1141 Flexible pavements.
Asphaltic concrete: To 1144 Asphaltic concrete (Roadways).
Cement concrete: To 1131 Rolled concrete subbase, 1132 Mass concrete subbase, 1133 Plain or reinforced concrete base, 1134 Steel fibre reinforced concrete or 1135 Continuously reinforced concrete base, as appropriate.
Sprayed bituminous seals: To 1143 Sprayed bituminous surfacing.
Concrete and clay segmental pavers: To 1145 Segmental paving.
Bituminous slurry surfacing (cold overlay): To 1146 Bituminous slurry surfacing.

### 2.6 CONSTRUCTION AND MAINTENANCE

**Considerations**
Construction and maintenance factors: Consider the following for the type of pavement, choice of base and subbase materials, and the type of surfacing adopted:
- Documentation of joints incorporated in the design.
- Extent and type of drainage.
- Use of boxed or full width construction.
- Available equipment of the Contractor.
- Use of stabilisation.
- Aesthetic, environmental and safety requirements.
- Social considerations.
- Construction under traffic.
- Use of staged construction.
- Ongoing and long-term maintenance costs.

### 3 PAVEMENT THICKNESS DESIGN

#### 3.1 PAVEMENT STRUCTURE

**Minimum pavement thickness**
Pavement thickness, including the thickness of surfacings:
- Roads with kerb and channel (gutter): 250 mm.
- Unkerbed roads: 200 mm.
- Car parks: 150 mm.

Final thickness of subbase and base layers:
- Flexible pavement: Subbase 100 mm, base 100 mm
- Rigid pavement: Subbase 100 mm, base 150 mm

**Subbase extent**
Subbase layer: Minimum of 150 mm behind the rear face of any kerb and/or channel (gutter).

**Base extent**
Base and surfacing: To the face of any kerbing and/or channel (gutter).
Kerb conditions: If the top surface of the subbase layer is below the level of the underside of the kerb channel (gutter), extend the base layer a minimum of 150 mm behind the rear face of the kerb and/or channel (gutter).
Unkerbed roads: Extend the subbase and base layers at least to the nominated width of shoulder.

**Carparks**
Concentrations: Allow for traffic load concentrations within carpark areas (e.g. entrances/exits).

**Drainage**
Precautions: Make provision for pavement layer drainage on the assumption that during the service life of the pavement ingress of water will occur.

### 3.2 PAVEMENT DESIGN

**Unbound granular flexible pavements – Bituminous surfaced**
Criteria: Design unbound granular flexible pavements with thin bituminous surfacings, including those with cement or lime modified granular materials, with design traffic up to $10^6$ ESAs to AGPT02 Figure 12.2.
For design traffic above $10^6$ ESAs, use AGPT02 Figure 8.4 (or software designed for this purpose).

**Flexible pavements containing bound layers—Bituminous surfaced**
Criteria: Design flexible pavements containing one or more bound layers, including cement stabilised layers or asphaltic concrete layers other than thin asphalt surfacings, to AGPT02 Section 8 (or software designed for this purpose).
Alternatively for design traffic up to $10^6$ ESAs: Assume bound layers to be equivalent to unbound layers of the same thickness, and design the pavement to AGPT02 Section 12.8.

**Rigid pavements**
Criteria: Design rigid (concrete) pavements, with design traffic up to $10^6$ ESAs to either CCAA-T51 Guide to residential streets and paths or AGPT02 Section 12.9 (or software designed for this purpose).
Criteria: Design rigid (concrete) pavements for design traffic above $10^6$ ESAs to AGPT02 Section 9 (or software designed for this purpose).

**Concrete segmental pavements**
Criteria: Design concrete segmental pavements with design traffic up to $10^6$ estimated commercial vehicles exceeding 3 T gross to CMAA-T45.

**Clay segmental pavements**
Criteria: Design clay segmental pavements with design traffic up to $10^6$ ESAs to CBPI Manual 1 – Clay paving design and construction and CBPI Techniques 15 - Design Considerations for Clay Paved Roadways.

### 4 SURFACING DESIGN

#### 4.1 SURFACE TYPE

**Streets**
Wearing surface specifications: Bituminous wearing surface as follows except where the pavement is designed for concrete or segmental block surfacing:
- Urban/rural residential streets: Access street and local street, alternatives:
  - primer seal plus two coat flush seal, or
  - primer seal, plus one coat flush seal, plus bituminous slurry surfacing; or
  - primer seal, plus asphalt.
- Urban/rural residential streets: Collector and local sub-arterial, alternatives:
  - primer seal, plus one coat flush seal, plus bituminous slurry surfacing; or
. primer seal, plus asphalt.
- Commercial and industrial streets:
  . primer seal, plus asphalt.

**Braking and turning zones**

Alternatives: Provide either bituminous slurry surfacing or asphalt surfacing with suitable binders at intersection approaches and cul-de-sac turning circles on residential streets with flush seals, within the vehicle braking and turning zones. Consider surfacing materials in braking zones to provide additional wear and roughness properties.

### 4.2 SURFACE TYPE PROPERTIES

**Sprayed bituminous seals (flush seals)**

Criteria: Sprayed bituminous (flush) seals, including primer seals to *AP-T68 sprayed seal design method – 2006: Summary* or to the relevant State Road Authorities’ Bituminous Surfacing Manual.

Primer seal: Indicate on the Drawings 7 mm primer seals below all flush seals, bituminous slurry surfacing, and asphalt surfacings. Conform to the following:

- Use size 5-7 mm aggregate < 200 v/l/d.
- Use 7-10 mm size aggregate > 200 v/l/d.
- If the conditions are either very hot and/or wet, and the traffic is in excess of 600 v/l/d, use size 10 mm aggregate.

Two-coat flush seals: Double-double seals, comprising a minimum of two coats binder and two coats of aggregate as follows:

- 1st coat—14 mm.
- 2nd coat—7 mm.

Single coat flush seal: If bituminous slurry surfacing (or asphaltic concrete) is to be applied as the finished surface, provide single coat flush seals either 14 mm or 10 mm thick.

**Bituminous slurry surfacing (cold overlay)**

Minimum thickness: 8 mm nominal compacted thickness.

Primer seal and single coat seal: Indicate on the Drawings a 7 mm primer seal and a single coat flush seal on the drawings below the bituminous slurry surfacing.

**Asphaltic concrete**

Light to medium traffic: In urban residential access and local streets, rural or light trafficked commercial streets (design traffic up to approximately $3 \times 10^5$ ESAs), design the asphalt mix as either a ‘high-bitumen content’ mix or a mix to AGPT02 Section 6.5 and 1144 Asphaltic concrete (Roadways).

Medium to heavy traffic: In urban residential collector and sub-arterial roads, medium to heavily trafficked rural and commercial streets and in all industrial roads, design the asphalt mix as a dense graded mix to 1144 Asphaltic concrete (Roadways).

Minimum thickness: Design asphaltic concrete surfacings to provide a nominal compacted layer thickness:

- On light to medium trafficked residential rural and commercial streets: > 25 mm
- On medium to heavily trafficked residential, rural or commercial roads: 40 mm.

Primer seal: Indicate a 7 mm or 10 mm primer seal on the drawings below the asphalt surfacing.

**Segmental pavers**

Size and shape: Conform to the following:

- Concrete segmental pavers: 80 mm thick, shape Type A, and designed to be paved in a herringbone pattern.
- Clay segmental pavers: 65 mm thick, Class 4, and designed to be paved in a herringbone pattern.

Edge restraint: Design the edges of all paving to be constrained by either kerbing and/or guttering, or by concrete edge strips.
5 DOCUMENTATION

5.1 GENERAL

Calculations
Requirements: Submit all considerations, assumptions, subgrade test results, and calculations with the pavement design for approval by Council.

Specifications
Construction documentation: Prepare technical specifications suitable for inclusion in the AUS-SPEC contract documentation system. Consider including Construction and Maintenance worksection Templates from the National Classification System workgroups 02, 03, 11, 13, 14-18.

Design certification
Requirement: Provide a signed and dated design certificate.

5.2 DRAWINGS

General
Requirements: Clearly indicate the structure, material types and layer thicknesses of the proposed pavement and surfacing.

5.3 WORK-AS-EXECUTED

General
Work-as-executed drawings: Provide additional set of final construction drawings for the purpose of recording the work-as-executed by the Contractor.