DEVELOPMENT DESIGN SPECIFICATION

D2

PAVEMENT DESIGN

CONTENTS

PAVEMENT DESIGN

GENERAL

D2.01 SCOPE

Design Criteria

1. The work to be executed under this Specification consists of the design of the road pavement to meet the required design life, based on the subgrade strength, traffic loading and environmental factors, and including the selection of appropriate materials for select subgrade, subbase, base and wearing surface.

Surfaced Pavement Types

2. The Specification contains procedures for the design of the following forms of surfaced road and carpark pavement construction:

(a) Flexible pavements consisting of unbound granular materials;

(b) Flexible pavements that contain one or more bound layers, including pavements containing asphalt layers other than thin asphalt wearing surfaces;

(c) Rigid pavements (ie. cement concrete pavements);

(d) Concrete or clay segmental block pavements.

D2.02 OBJECTIVES

Pavement Performance

1. The objective in the design of the road pavement is to select appropriate pavement and surfacing materials, types, layer thicknesses and configurations to ensure that the pavement performs adequately and requires minimal maintenance under the anticipated traffic loading for the design life adopted.

D2.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

D1	-	Geometric Road Design
D4	-	Subsurface Drainage Design
C242	-	Flexible Pavements
C244	-	Sprayed Bituminous Surfacing
C245	-	Asphaltic Concrete
C247	-	Mass Concrete Subbase
C248	-	Plain or Reinforced Concrete Base
C254	-	Segmental Paving
C255	-	Bituminous Microsurfacing
C271		Minor Concrete Works

(b) State Authorities

Roads and Traffic Authority, NSW - Sprayed Sealing Guide, 1992.
Roads and Traffic Authority, NSW – Form 76, Guide to the Structural Design of Road Pavements.

(c) Other

AUSTROADS - Pavement Design, A Guide to the Structural Design of Road Pavements, 1992.

AUSTROADS - Guide to Control of Moisture in Roads.

ARRB - Australian Road Research Board - APRG REPORT No.21 - A Guide to the Design of New Pavements for Light Traffic, 1998.

CACA - T33 - Cement and Concrete Association, T33 - Concrete Street and Parking Area Pavement Design, 1984.

CACA - T35 - Cement and Concrete Association, T35 - Interlocking Concrete Road Pavements, A Guide to Design and Construction, 1986.

CACA - TN52 - Cement and Concrete Association, TN52 - Single-Lane Concrete Bus Bays, 1984.

Clay Brick and Paver Institute
- Design Manual 1 - Clay Segmental Pavements, A Design and Construction Guide for Sites Subjected to Vehicular and Pedestrian Traffic, 1989.

PAVEMENT DESIGN CRITERIA

D2.04 DESIGN VARIABLES

1. Regardless of the type of road pavement proposed, the design of the pavement shall involve consideration of the following five input variables:

Design Variables

(a) Design Traffic
(b) Subgrade Evaluation
(c) Environment
(d) Pavement and Surfacing Materials
(e) Construction and Maintenance Considerations

D2.05 DESIGN TRAFFIC

1. The design traffic shall be calculated based on the following minimum design lives of pavement: -

Minimum Pavement Design Life

(a) Flexible, Unbound Granular - 25 years
(b) Flexible, Containing one or more bound layers - 25 years
(c) Rigid (Concrete) - 40 years
(d) Segmental Block - 25 years

2. Design traffic shall be calculated 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. For new subdivisions, the design traffic shall take account of both the construction traffic associated with the subdivision development and the in-service traffic. For interlocking concrete segmental pavements, the simplification of replacing ESA's with the number of

Design Traffic

commercial vehicles exceeding 3 tonne gross contained in CACA - Interlocking Concrete Road Pavements is acceptable up to design traffic of 10^6. Beyond this, ESAs should be calculated. However, the use of interlocking concrete segmental paving will not be approved for pavements that will transfer into Council's ownership.

3. The pavement design shall include all traffic data and/or assumptions made in the calculation of the design traffic. ***Traffic Data***

4. In general, reference should be made to ARRB – APRG Report No.21 for the calculation of design traffic volumes for urban roads up to $5x10^5$ ESAs, and AUSTROADS Pavement Design Guide for all other cases. ***Design Traffic Volumes***

5. In the absence of other traffic data, the following traffic values (in ESAs) may be taken as a guide to the design traffic, but shall be subject to variation depending on the circumstances for the particular development. Note that these values take precedence over the values shown in Tables 13.7.3 and 13.7.4 of ARRB – APRG Report No.21. ***Design ESAs***

Street Type:		**Design ESA's - 25 year design life**
Urban Residential	- Cul-de-sac (up to 15 lots)	5×10^4
	- Access	3×10^5
	- Collector	1×10^6
	- Local Distributor	2×10^6
Rural Residential	- Cul-de-sac (up to 10 lots)	5×10^4
	- Other	3×10^5
Rural	- Up to 1000 AADT	1×10^6
	- Over 1000 AADT	2×10^6
Access to Rural Industries on private property		1×10^6
Commercial and Industrial		5×10^6
Carparks	- Cars only	5×10^4
	- Subject to commercial vehicles	5×10^5

D2.06 SUBGRADE EVALUATION

1. Except where a mechanistic design approach is employed using AUSTROADS Pavement Design, the measure of subgrade support shall be the California Bearing Ratio (CBR). Where a mechanistic design approach using linear elastic theory is employed for flexible pavements, the measure of subgrade support shall be in terms of the elastic parameters (modulus, Poisson's ratio). ***California Bearing Ratio***

2. The following factors must be considered in determining the design strength/stiffness of the subgrade: ***Design Considerations***

(a) Sequence of earthworks construction

(b) The compaction moisture content and field density specified for construction

(c) Moisture changes during service life

(d) Subgrade variability

(e) The presence or otherwise of weak layers below the design subgrade level.

3. The subgrade Design CBR adopted for the pavement design must consider the effect of moisture changes in the pavement and subgrade during the service life, and hence consideration must be given to the provision of subsurface drainage in the estimation of equilibrium in-situ CBRs, and hence in the design of the pavement structure. Warrants for the provision of subsurface drainage are given in Development Design Specification (D.4) ***Design CBR***

SUBSURFACE DRAINAGE DESIGN. If subsurface drainage is not provided, then the Design CBR adopted must allow for a greater variability in subgrade moisture content during the service life of the pavement, and hence a Design Moisture Content above the Optimum Moisture Content.

4. The calculation of the Design CBR shall be based on a minimum of three 4 day soaked CBR laboratory samples for each subgrade area, compacted to the relative density specified for construction at the design moisture content to give an estimated equilibrium in-situ CBR. The Design CBR for each subgrade area is computed by using the appropriate formulae as follows: ***Calculation of Design CBR***

Design CBR = Least of estimated equilibrium CBRs, for less than five results

Design CBR = 10th percentile of all estimated equilibrium CBRS, for five or more results

= C - 1.3S

Where C is the mean of all estimated equilibrium CBRs, and
S is the standard deviation of all values.

5. The Design CBR obtained from laboratory testing shall be confirmed by testing performed on existing road pavements that have been sealed for at least three years and that are near to the job site, under equivalent conditions and displaying similar subgrade. The testing shall determine an estimate of the in-situ subgrade CBR by back calculation from Benkelman Beam deflection analysis, using the method set down in Section 5.5 of RTA Form 76. ***Field Confirmation***

6. The pavement design shall include a summary of all laboratory and field test results and assumptions and/or calculations made in the assessment of Design CBR. ***Summary of Results***

D2.07 ENVIRONMENT

1. The environmental factors that significantly affect pavement performance are moisture and temperature. Both of these factors must be considered at the design stage of the pavement. Reference should be made to AUSTROADS Pavement Design, ARRB – APRG Report No.21, and to AUSTROADS - Guide to Control of Moisture in Roads. ***Reference***

2. The following factors relating to moisture environment must be considered in determining the design subgrade strength/stiffness and in the choice of pavement and surfacing materials:

(a) Rainfall/evaporation pattern
(b) Permeability of wearing surface
(c) Depth of water table
(d) Relative permeability of pavement layers
(e) Whether shoulders are sealed or not
(f) Pavement type (boxed or full width)

3. The effect of changes in moisture content on the strength/stiffness of the subgrade shall be taken into account by evaluating the design subgrade strength parameters (i.e. CBR or modulus) at the highest moisture content likely to occur during the design life, ie the Design Moisture Content. The provision of subsurface drainage may, under certain circumstances, allow a lower Design Moisture Content, and hence generally higher Design CBR. ***Evaluate Design CBR***

4. The effect of changes in temperature environment must be considered in the design of pavements with asphalt wearing surfaces, particularly if traffic loading occurs at night when temperatures are low, thus causing a potential reduction in the fatigue life of thin asphalt ***Temperature Change***

surfacing. The effect of changes in temperature environment should also be considered for bound or concrete layers.

5. The pavement design shall 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.

D2.08 PAVEMENT AND SURFACING MATERIALS

Pavement Classification

1. Pavement materials can be classified into essentially four categories according to their fundamental behaviour under the effects of applied loadings:

(a) Unbound granular materials, including modified granular materials

(b) Bound (cemented) granular materials

(c) Asphaltic Concrete

(d) Cement Concrete

Surfacing Classification

2. Surfacing materials can also be classified into essentially five categories or types:-

(a) Sprayed bituminous seals (flush seals)

(b) Asphaltic concrete

(c) Cement Concrete

(d) Concrete Segmental Pavers

(e) Clay Segmental Pavers

3. Unbound granular materials, including modified granular materials, shall satisfy the requirements of the Construction Specification for FLEXIBLE PAVEMENTS.

4. Bound (cemented) granular materials shall satisfy the requirements of the Construction Specification for FLEXIBLE PAVEMENTS.

5. Asphaltic concrete shall satisfy the requirements of the Construction Specification for ASPHALTIC CONCRETE.

6. Cement concrete shall satisfy the requirements of the Construction Specifications for MASS CONCRETE SUBBASE, PLAIN OR REINFORCED CONCRETE BASE or FIBRE REINFORCED CONCRETE, as appropriate.

7. Sprayed bituminous seals shall satisfy the requirements of the Construction Specification for SPRAYED BITUMINOUS SURFACING.

8. Concrete and clay segmental pavers shall satisfy the requirements of Construction Specification C254 SEGMENTAL PAVING. It should be noted that the use of neither clay nor concrete segmental paving will be approved within any road pavement that will come under the care and control of Council.

D2.09 CONSTRUCTION AND MAINTENANCE CONSIDERATIONS

1. The type of pavement, choice of base and subbase materials, and the type of surfacing adopted should involve consideration of various construction and maintenance factors as follows:

(a) Extent and type of drainage

(b) Use of boxed or full width construction

(c) Available equipment of the Contractor

(d) Use of stabilisation

(e) Aesthetic, environmental and safety requirements

(f) Social considerations

(g) Construction under traffic

(h) Use of staged construction

(i) Ongoing and long-term maintenance costs

These factors are further discussed in AUSTROADS Pavement Design.

Designers are referred to Council's Unformed Roads Policy for the design requirements for unformed roads

PAVEMENT THICKNESS DESIGN

D2.10 PAVEMENT STRUCTURE - GENERAL

Minimum Pavement Thickness

1. The minimum thickness of flexible pavements, excluding the thickness of surfacing, shall be not less than 300mm. The only exception is for lightly trafficked sealed private access roads (excluding access to rural industries), where the pavement thickness may be reduced to 250mm. 250mm thick pavements shall only be approved where it can be demonstrated that:
   a. There is a very low probability of regular or frequent heavy vehicle use, and
   b. The pavement design is rigorous, in accordance with accepted design standards, and demonstrates that the pavement should fulfil its design service live. All design criteria are to be clearly stated in the design submission

2. Notwithstanding subgrade testing and subsequent pavement thickness design, the thickness of subbase and base layers for all sealed pavements other than private access roads shall not be less than the following: -

(a)	Flexible pavement:	Subbase 200mm, Base 100mm
(b)	Rigid pavement:	Subbase 100mm, Base 150mm

Subbase Extent

3. The subbase layer shall extend a minimum of 150mm behind the rear face of any kerbing and/or guttering.

Base Extent

4. The base and surfacing shall extend to the face of any kerbing and/or guttering. Where the top surface of the subbase layer is below the level of the underside of the kerbing and/or guttering, the base layer shall also extend a minimum of 150mm behind the rear face of the kerbing and/or guttering.

5. For unkerbed roads, the subbase and base layers shall extend at least to the nominated width of shoulder.

Unsealed Pavements

6. Unsealed pavements shall be designed in accordance with the ARRB - APRG Report No.21.

D2.11 UNBOUND GRANULAR FLEXIBLE PAVEMENTS (BITUMINOUS SURFACED)

1. Unbound granular flexible pavements with thin bituminous surfacing, including those with cement or lime modified granular materials, with design traffic up to $5x10^5$ ESAs shall be designed in accordance with ARRB – APRG Report No.21, 13.8.2.

2. For design traffic above $5x10^5$ ESAs, the design shall be in accordance with AUSTROADS Pavement Design.

D2.12 FLEXIBLE PAVEMENTS CONTAINING BOUND LAYERS (BITUMINOUS SURFACED)

1. Flexible pavements containing one or more bound layers, including cement stabilised layers or asphaltic concrete layers other than thin asphalt surfacing, shall be designed in accordance with AUSTROADS Pavement Design.

2. As an alternative to AUSTROADS Pavement Design for design traffic up to $5x10^5$ ESAs, bound layers may be assumed to be equivalent to unbound layers of the same thickness, and the pavement designed in accordance with ARRB – APRG Report No.21, 13.8.2.

D2.13 RIGID PAVEMENTS

Rigid (Concrete)

1. Rigid (concrete) pavements, with design traffic up to 10^6 ESAs shall be designed in accordance with either CACA -T33 or AUSTROADS Pavement Design.

2. Rigid (concrete) pavements for design traffic above 10^6 ESAs, the design shall be in accordance with AUSTROADS Pavement Design.

3. Single lane concrete bus bays adjacent to a flexible pavement shall be designed in accordance with CACA -TN52.

D2.14 CONCRETE SEGMENTAL BLOCK PAVEMENTS

Concrete Segmental Block

1. Concrete segmental block pavements with design traffic up to 10^6 estimated commercial vehicles exceeding 3T gross shall be designed in accordance with CACA -T35. The thickness of the base shall be not less that 150mm.

2. For design traffic above 10^6 estimated commercial vehicles exceeding 3T gross the design shall be in accordance with AUSTROADS Pavement Design, with the calculation of design traffic in terms of ESAs.

D2.15 CLAY SEGMENTAL BLOCK PAVEMENTS

Clay Segmental Block

1. Clay segmental block pavements with design traffic up to 10^6 ESAs shall be designed in accordance with Design Manual 1 – Clay Segmental Pavements. The thickness of the base shall be not less that 150mm.

2. For design traffic above 10^6 ESAs and up to 10^7 ESAs the design shall involve consideration of both Design Manual 1 - Clay Segmental Pavements and AUSTROADS Pavement Design, with the thicker and more conservative design of each of the two methods adopted.

3. For design traffic above 10^7 ESAs, the pavement shall be designed in accordance with AUSTROADS Pavement Design.

SURFACING DESIGN

D2.16 CHOICE OF SURFACE TYPE

Bitumen Wearing Surface

1. Except where the pavement is designed for concrete, segmental block surfacing or unsealed pavements, the wearing surface shall be a bituminous wearing surface is as follows: -

(a) Urban Residential roads: -

- prime, plus asphalt.

(b) Rural Roads: -

- prime, plus two coat flush seal

(c) Commercial and Industrial roads:

- primer seal or single coat seal, plus asphalt

2. At intersection approaches and cul-de-sac turning circles on residential roads with flush seals, either bituminous microsurfacing or asphalt surfacing shall be provided within the vehicle braking and turning zones. ***Braking and Turning Zones***

3. Where a private access road gives access onto a sealed public road, the access road shall be sealed between the edge of the public road carriageway and the property boundary. ***Private Access***

4. Council may approve variations to these requirements in special circumstances. ***Approval***

D2.17 SPRAYED BITUMINOUS SEALS (FLUSH SEALS)

1. The design of sprayed bituminous (flush) seals, including primer seals, shall be in accordance with the RTA Sprayed Sealing Guide. ***Seal Design***

2. Prime coat shall be indicated on the Drawings below all flush seals and asphalt surfacing. For commercial or industrial development, where a 7mm primer seal is impractical, a 10mm flush seal shall be indicated in lieu. ***Primer Seal***

3. Two-coat flush seals shall be double-double seals, comprising a minimum of two coats binder and two coats of aggregate. The preferred seal types are: ***Two- Coat Flush Seals***

1st coat	14mm
2nd coat	7mm

D2.18 ASPHALTIC CONCRETE

1. In light to medium trafficked residential, rural or commercial roads (design traffic up to approximately $5x10^5$ ESAs), the asphalt mix design shall be either a 'high-bitumen content" mix or the ARRB Gap-graded mix in accordance with ARRB-SR41 and the Construction Specification for ASPHALTIC CONCRETE. ***Light to Medium Traffic***

2. In medium to heavily trafficked residential, rural or commercial roads and in all industrial and classified roads, the asphalt mix design shall be a dense graded mix in accordance with the Construction Specification for ASPHALTIC CONCRETE. ***Medium to Heavy Traffic***

3. Asphaltic concrete surfacing shall be designed to provide a nominal compacted layer thickness of not less than 30mm on carparks and residential roads with design traffic less than or equal to $5x10^5$, and 40mm on all other residential roads, commercial and industrial roads, classified roads, including carpark lanes providing access to loading docks. ***Minimum Thickness***

4. As a minimum, a 7mm or 10mm primer seal shall be indicated on the Drawings below the asphalt surfacing. ***Primer Seal***

5. All asphaltic concrete shall have the pavement retained by suitable retainment including concrete edge strips or kerb and gutter.

D2.19 SEGMENTAL PAVERS

1. Concrete segmental pavers shall be 80mm thick, shape Type A, and designed to be paved in a herringbone pattern. ***Size and Shape***

2. Clay segmental pavers shall be 65mm thick, Class 4, and designed to be paved in a herringbone pattern.

3. The design shall constrain the edges of all paving by either kerbing and/or guttering, or by concrete edge strips. ***Edge Constraint***

D2.20 COMBINED DRIVEWAY/ACCESSWAYS

1. Where a rigid pavement is proposed, it shall consist of concrete that shall as a minimum be of 25 MPa compressive strength at 28 days, 150mm thick, reinforced with F72 mesh and placed in accordance with specification C271 MINOR CONCRETE WORKS. A structural design shall be carried out as required. ***Rigid Pavement***

2. Flexible pavements shall be designed as per Section D2.10 ***Flexible Pavement***

DOCUMENTATION

D2.21 DESIGN CRITERIA AND CALCULATIONS

1. The final pavement design shall be submitted with the Construction Certificate application for Council's Development Engineer's approval. All considerations, assumptions, subgrade test results and calculations shall be submitted with the pavement design. ***Submission Details***

2. The Drawings shall clearly indicate the structure, material types and layer thicknesses of the proposed pavement and surfacing. ***Drawings***