ENGINEERING DESIGN SPECIFICATION

D2

FLEXIBLE PAVEMENT DESIGN

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GENERAL

D2.01 SCOPE

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, sub-base, base and wearing surface. ***Design Criteria***

2. The Specification contains procedures for the design of the following forms of surfaced road pavement construction: ***Surfaced Pavement Types***

   (i) flexible pavements consisting of unbound granular materials;

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

   (iii) rigid pavements (ie. cement concrete pavements);

   (iv) concrete or clay segmental block pavements.

3. Consideration to the design of unsealed (gravel) pavements will only be given for minor rural subdivisions/developments in isolated rural areas where the access to the subdivision is via an existing unsealed road. ***Unsealed Pavements***

D2.02 OBJECTIVES

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. ***Pavement Performance***

D2.03 REFERENCE DOCUMENTS

1. Council Specifications and Design Manuals and Standards are referred to in abbreviated form (eg SR41). For convenience, the full titles are given below:– ***Specifications and Design Standards***

   (a) Council Specifications

D1	Geometric Road Design
D4	Sub-surface Drainage Design
C242	Flexible Pavements
C244	Sprayed Bituminous Surfacing
C245	Asphaltic Concrete
C247	Mass Concrete Sub-base
C248	Plain or Reinforced Concrete Base
C254	Segmental Paving
C255	Bituminous Micro-surfacing
C278	Fibre Reinforced Concrete

(b) Design Manuals/Standards

ARRB–SR41	Australian Road Research Board, Special Report No. 41 – A Structural Design Guide for Flexible Residential Street Pavements, 1989.
AUSTROADS Pavement Design	AUSTROADS – Pavement Design, A Guide to the Structural Design of Road Pavements, 1992.
C+CA – T35	Cement and Concrete Association, T35 – Interlocking Concrete Road Pavements, A Guide to Design and Construction, 1986.
C+CA – T33	Cement and Concrete Association, T33 – Concrete Street and Parking Area Pavement Design, 1984.
C+CA – TN52	Cement and Concrete Association, TN52 – Single-Lane Concrete Bus Bays, 1984.
Design Manual 1 Segmental Pavements	Knapton and Mavin, Clay Brick and Paver Institute, Clay Design Manual 1 – Clay Segmental Pavements, A Design and Construction Guide for Sites Subjected to Vehicular and Pedestrian Traffic, 1989.
RTA Sprayed Sealing Guide	Roads and Traffic Authority, NSW – Sprayed Sealing Guide, 1992.

PAVEMENT DESIGN CRITERIA

D2.04 DESIGN VARIABLES

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:

   (i) Design Traffic

   (ii) Subgrade Evaluation

   (iii) Environment

   (iv) Pavement and Surfacing Materials

   (v) Construction and Maintenance Considerations

D2.05 DESIGN TRAFFIC

Minimum Pavement Design Life

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

   (i) Flexible, Unbound Granular – 25 years

   (ii) Flexible, Containing one or more bound layers – 25 years

   (iii) Rigid (Concrete) – 40 years

   (iv) Segmental Block – 25 years

Equivalent Standard Axles

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 commercial vehicles exceeding 3 tonne gross contained in C+CA – Interlocking Concrete Road Pavements is acceptable up to a design traffic of 10^6. Beyond this, ESAs should be calculated.

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–SR41 for the calculation of design traffic volumes up to 10^6 ESAs and AUSTROADS Pavement Design for design traffic volumes approaching or exceeding 10^6 ESAs. ***Design References***

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. ***Assumed Values***

Street Type: Design ESA's – 25 year design life

Urban Residential	– Cul-de-sac (less than 15 dwellings)	1×10^4	
	– Minor (15 to 50 dwellings)	1×10^4-	5×10^4
	– Local Access (50 to 100 dwellings)	5×10^4-	1×10^5
	– Collector (100 to 300 dwellings)	1×10^5-	1×10^6
	– Distributor	2×10^6	
	– Arterial	Refer Austroads Guidelines	
Rural Residential	– Cul-de-sac		2×10^4
	– Other		3×10^5
Commercial and Industrial			1×10^6

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). ***Subgrade Strength***

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

   (i) Sequence of earthworks construction

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

   (iii) Moisture changes during service life

   (iv) Subgrade variability

   (v) 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 sub-surface drainage in the estimation of equilibrium in-situ CBRs, and hence in the design of the pavement structure. Warrants for the provision of sub-surface drainage are given in Specification for SUBSURFACE DRAINAGE DESIGN. If sub-surface 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. ***Design CBR*** ***Design 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, and corrected to allow for the effects of subsurface drainage (or lack of), climatic zone, and soil type if appropriate (as per the guidelines in ARRB SR41) to give an estimated equilibrium in-situ CBR. ***Minimum Testing***

The design CBR for each subgrade area is computed by using the appropriate formulae as follows:

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.

The frequency of test holes for determining the design CBR is to be as follows:

Purpose of Test Holes	Short Streets <120m	Long Streets >120m
Laboratory testing performed on each different subgrade soil sampled (soaked CBR's and soil classification tests).	Sampling to be performed at 2 or 3 sites; laboratory testing carried out on relevant materials. The aim should be to perform tests on three samples at the one soil type.	Sampling to be performed at one site every 60 to 100m; laboratory testing carried out on relevant materials. The aim should be to perform tests on three samples of the one soil.

5. Where practicable, the Design CBR obtained from laboratory testing should be confirmed by testing performed on existing road pavements near to the job site under equivalent conditions and displaying similar subgrades. ***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 which 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–SR41, and to NAASRA – Guide to Control of Moisture in Roads. ***Moisture and Temperature Considerations***

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: ***Factors***

(i) Rainfall/evaporation pattern

(ii) Permeability of wearing surface

(iii) Depth of water table

(iv) Relative permeability of pavement layers

(v) Whether shoulders are sealed or not

(vi) 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 (ie. CBR or modulus) at the highest moisture content likely to occur during the design life, ie the Design Moisture Content. The provision of sub-surface drainage may, under certain circumstances, allow a lower Design Moisture Content, and hence generally higher Design CBR. *Design Moisture Content*

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

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

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

   (i) Unbound granular materials, including modified granular materials

   (ii) Bound (cemented) granular materials

   (iii) Asphaltic Concrete

   (iv) Cement Concrete

2. Surfacing materials can also be classified into essentially five categories or types:– *Surfacing Types*

   (i) Sprayed bituminous seals (flush seals)

   (ii) Asphaltic concrete and bituminous micro-surfacing (cold overlay)

   (iii) Cement Concrete

   (iv) Concrete Segmental Pavers

   (v) Clay Segmental Pavers

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

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 the Construction Specification for SEGMENTAL PAVING.

9. Bituminous micro-surfacing (cold overlay) shall satisfy the requirements of the Construction Specification for BITUMINOUS MICROSURFACING.

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: ***Construction and Maintenance Factors***

   (i) Extent and type of drainage

   (ii) Use of boxed or full width construction

   (iii) Available equipment of the Contractor

   (iv) Use of stabilisation

   (v) Aesthetic, environmental and safety requirements

   (vi) Social considerations

   (vii) Construction under traffic

   (viii) Use of staged construction

   (ix) Ongoing and long-term maintenance costs

   These factors are further discussed in AUSTROADS Pavement Design.

PAVEMENT THICKNESS DESIGN

D2.10 PAVEMENT STRUCTURE – GENERAL

1. The pavement thickness, including the thickness of surfacings, shall not be less than 250mm for roads in which kerb and guttering is to be constructed, and 200mm for unkerbed roads ***Minimum Pavement Thickness***

2. Notwithstanding subgrade testing and subsequent pavement thickness design, the thickness of sub-base and base layers shall not be less than the following:– ***Layer Thickness***

   (i) Flexible pavement: Sub-base 100mm, Base 100mm

   (ii) Rigid pavement: Sub-base 100mm, Base 150mm

3. The sub-base layer shall extend a minimum of 150mm behind the rear face of any kerbing and/or guttering. ***Layer Width***

4. The base and surfacing shall extend to the face of any kerbing and/or guttering. Where the top surface of the sub-base 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 sub-base and base layers shall extend at least to the nominated width of shoulder.

   Compaction : Gravel roads 95% standard proctor
   Bitumen sealed 98% modified proctor

D2.11 UNBOUND GRANULAR FLEXIBLE PAVEMENTS (BITUMINOUS SURFACED)

1. 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 shall be designed in accordance with ARRB–SR41, using Figure D2.11.1. ***Unbound Granular Flexible***

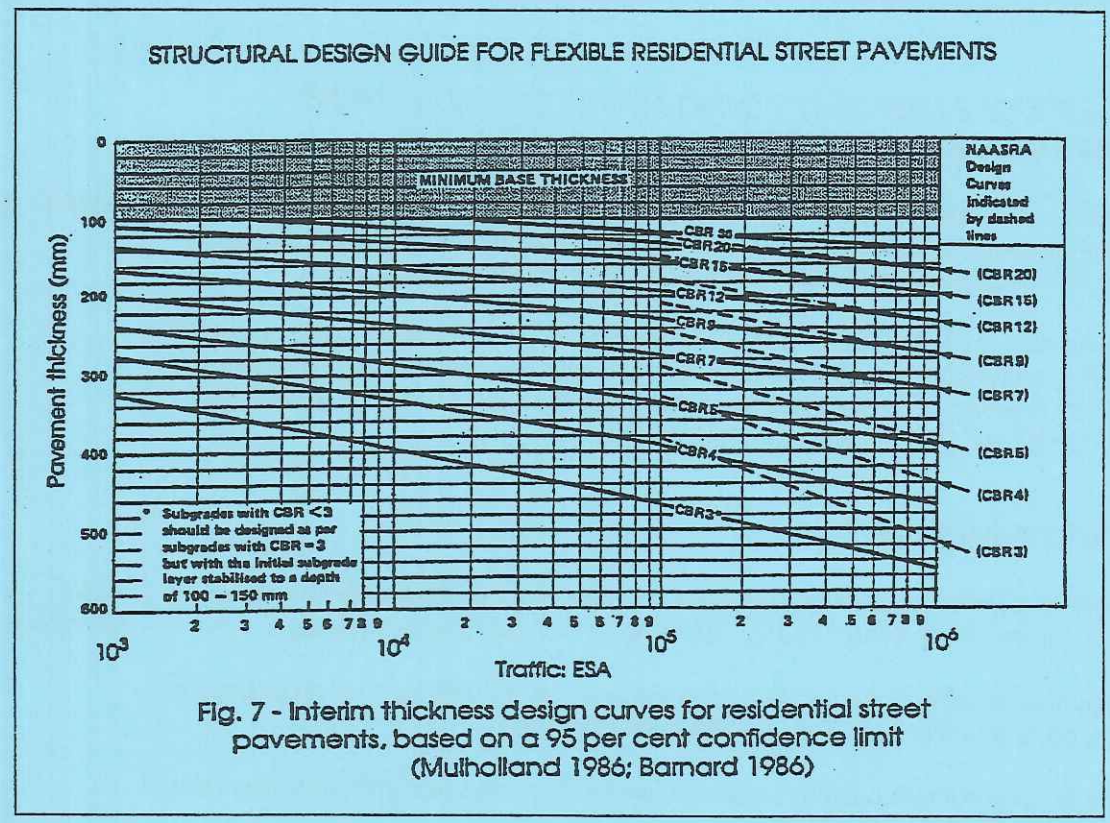

Fig. 7 - Interim thickness design curves for residential street pavements, based on a 95 per cent confidence limit (Mulholland 1986; Barnard 1986)

Fig D2.11.1

Interim thickness design curves for residential street pavements, based on a 95% confidence limit (Mulholland 1986; Barnard 1986)

2. For design traffic above 10^6 ESAs, the design shall be in accordance with AUSTROADS Pavement Design.

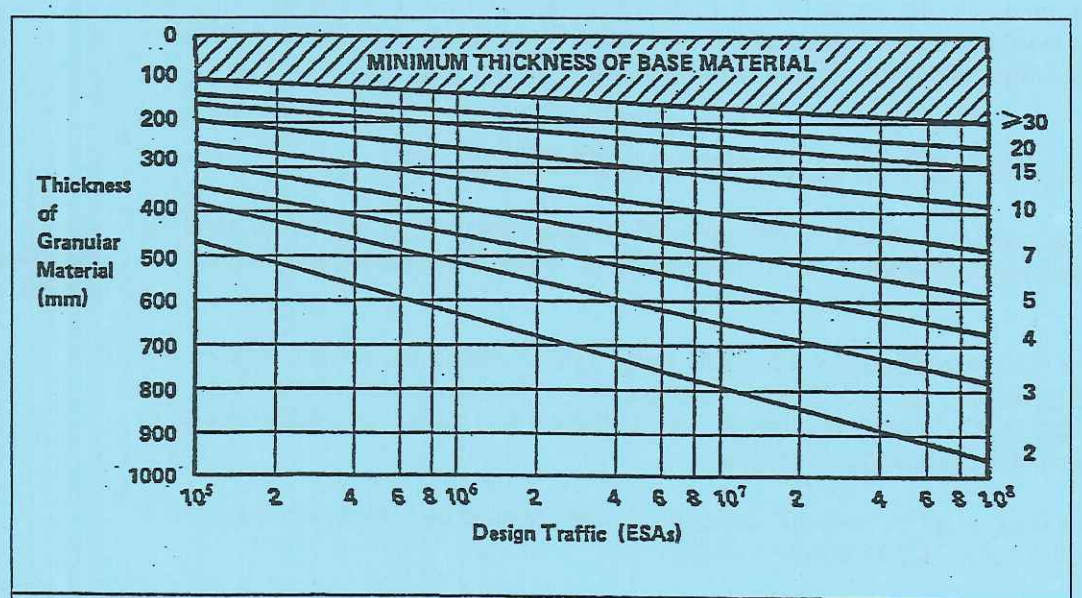

FIGURE 8.4 DESIGN CHART FOR GRANULAR PAVEMENTS WITH THIN BITUMINOUS SURFACING

Fig D2.11.2

Interim thickness design curves for residential streets pavements, based on a 90% confidence limit (Barnard 1986)

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

Bound Layers

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

2. As an alternative to AUSTROADS Pavement Design for design traffic up to 10^6 ESAs, bound layers may be assumed to be equivalent to unbound layers of the same thickness, and the pavement designed in accordance with ARRB–SR41, using Figure 7 (95% confidence limit curves).

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 C+CA –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 C+CA –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 C+CA –T35.

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.

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

Surface Type

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

   (i) Urban Residential streets – Cul-de-sac, Minor and Local Access, Collector and Distributor

   – primer seal, plus asphalt for new works in residential subdivisions.

   (II) Commercial and Industrial streets:

   – primer seal, plus asphalt.

   (iii) Sub-arterial and Arterial roads:

   – primer seal, plus asphalt.

   (iv) Rural Residential

   – two coat flush seal with concrete edge strip.

   (v) Rural Roads

   – two coat flush seal.

D2.17 SPRAYED BITUMINOUS SEALS (FLUSH SEALS)

Seal Design

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

Primer Seal

2. 7mm primer seals shall be indicated on the Drawings below all flush seals, bituminous micro-surfacing, and asphalt surfacings. Where a 7mm primer seal is impractical, a 10mm primer seal shall be indicated in lieu.

2 Coat Seals

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:

   1st coat 14mm

   2nd coat 7mm.

Single Coat Seal

4. Single coat flush seals shall be allowable if bituminous microsurfacing (or asphaltic concrete) is to be applied as the finished surface. The preferred seal type is either 14mm or 10mm.

D2.18 BITUMINOUS MICROSURFACING (COLD OVERLAY)

Minimum Thickness

1. Bituminous micro-surfacing, also referred to as 'cold overlay', shall be designed to provide a nominal compacted thickness of not less than 8mm.

Primer Seal and Single Coat Seal

2. As a minimum, a 7mm primer seal and a single coat flush seal shall be indicated on the Drawings below the bituminous micro-surfacing.

D2.19 ASPHALTIC CONCRETE

1. In light to medium trafficked residential, rural or commercial streets (design traffic up to approximately 3 x 10^5 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. ***High-Bitumen or Gap-Graded Mix***

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. ***Dense Graded Mix***

3. Asphaltic concrete surfacings shall be designed to provide a nominal compacted layer thickness of not less than 25mm on light to medium trafficked residential, rural and commercial streets, and 40mm on medium to heavily trafficked residential, rural or commercial roads and on all industrial and classified roads. ***Minimum Thickness***

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

D2.20 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 edges of all paving shall be designed to be constrained by either kerbing and/or guttering, or by concrete edge strips. ***Edge Constraint***

DOCUMENTATION

D2.21 DESIGN CRITERIA AND CALCULATIONS

1. All considerations, assumptions, subgrade test results, and calculations shall be submitted with the pavement design for approval by Council. ***Submission Details***

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

SPECIAL REQUIREMENTS

D2.22 RESERVED

D2.23 RESERVED

D2.24 RESERVED

D2.25 RESERVED