MACKAY CITY COUNCIL

ENGINEERING DESIGN GUIDELINES

PAVEMENT DESIGN

Planning Scheme Policy No. 15.02

DATE POLICY TOOK EFFECT:
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Contents

1 Scope and general

1.1 Scope

This section sets out the guidelines for 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 subgrade, sub-base, base and wearing surface.

The Guideline contains procedures for the design of the following forms of surfaced road pavement construction:

(a) Flexible pavements consisting of unbound 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 (i.e. cement concrete pavements);

(d) Concrete or clay segmental pavements

The design of unsealed (gravel) pavements will only be required for low trafficked rural access roads in isolated areas where express prior approval has been given by Council.

1.2 Objective

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.

1.3 Referenced documents

Council Guidelines & Specifications

D1 - Geometric Road Design
D4 - Subsurface Drainage Design
D20 - Drawing and Documentation Guideline
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
Standard Drawings (various)
Mackay City Council – Drawing and Documentation Guidelines - D20
Mackay Four Level Road Hierarchy *Eppell Olsen & Partners (August 2003)*

Other

Aust Roads - Pavement Design, A Guide to the Structural Design of Road Pavements, AP-G17/04.
- Technical Report – Pavement Design for Light Traffic – A Supplement to Aust Roads Pavement Design Guide AP-T36/06..

Aust Roads - Asphalt Guide, 2002.
Aust Roads - Aust Roads Provisional Sprayed Seal Method – Revision 2000.
Aust Roads - Guide to Control of Moisture in Roads
ARRB - Sealed Local Roads Manual, 1995.

Department of Main Roads
- Standard Specification MRS11.05 Unbound Pavements

Concrete Masonry Association of Australia.
CMAA – T44 - Concrete Segmental Pavements – Guide to Specifying, 1997.
CMAA – T45 - Concrete Segmental Pavements – Design Guide for Residential Access Ways and Roads, 1997.
CMAA – T46 - Concrete Segmental Pavements – Detailing Guide, 1997.

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.

1.4 Pavement Design Criteria

1.4.1 Design Variables

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

(a) Design Traffic

(b) Subgrade Evaluation

(c) Environment

(d) Pavement and Surfacing Materials

(e) Construction and Maintenance Considerations

A suitably qualified and experienced professional engineer (RPEQ), using an acceptable approach outlined in this Guideline shall determine the road pavement thickness and material types.

1.5 Design Traffic

1.5.1 General

The design traffic shall be determined based on the following minimum pavement design life:-

(a) Urban Streets and Roads – 25 years

(b) Rural Streets and Roads – 20 years

(c) Commercial and Industrial Streets and Roads – 25 Years

(d) Rigid (Concrete) – 40 years

(e) Segmental Block – 30 years

Design traffic shall be calculated in equivalent standard axles (ESA's) 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 and areas identified for future development or redevelopment, the design traffic shall take account of both the construction traffic associated with the developments and the in service traffic for the subdivisions and any future developments within the likely traffic catchment for the street or road.

For 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 $1x10^6$. Beyond this, ESA's should be calculated.

The pavement design report shall include all traffic data and/or assumptions made in the calculation of the design traffic. Where practicable, traffic data shall be based on actual traffic counts (less than 3 years old) undertaken by either Council or the engineer.

In determining the AADT/ESA's for any specific road in rural areas, the engineer shall take into account any seasonal use factors of the road – generally cane haulage.

Any traffic count used to determine the AADT shall be for a minimum of 72 hours and be taken to achieve an appropriate determination of the AADT, peak hour volumes and percentage use by commercial vehicles.

Council will provide all available relevant traffic data held, upon request. The Designer will be responsible for the cost of obtaining traffic data not held by Council.

In the absence of actual traffic data, the following traffic values (in ESA's) may be taken as a guide to the minimum design traffic, but shall be subject to variation depending on the circumstances for the particular traffic generating catchment for the street.

Street Type: Design ESA's

Access Place (Urban)	2×10^4
Access Street (Urban)	3.5×10^4
Access Place (Rural)	4×10^4
Access Street (Rural)	1×10^5
Industrial (Access & Collector)	5×10^5 (To be determined by specific design data)
Minor Collector	1 x 106
Major Collector	2 x 106 (To be determined by specific design data)
Sub Arterial	2 x 106 (To be determined by specific design data)

For roads of higher order than those listed above, design traffic determination shall be on a case by case basis for a design life of not less than 25 years.

In new estates, or where traffic figures are not able to be accurately determined, the Designer may use the following data to determine the design traffic loading in lieu of an approved alternative approach:

• Construction traffic	20 ESA/equivalent allotment
• Traffic generation rates	10vpd/allotment (residential development)
• Annual Traffic growth rates	0.5% (local residential street – post fully developed)
	2.0% (minor collector residential street)
	3.0% (major collector streets)
	3.5% (arterial and sub-arterial roads)
• Commercial Vehicles	3% (local residential streets)
	7% (minor collector street)
	8% (industrial access and collectors streets)
	5% (major collector street)
• ESA/HVAG	0.3 ESA/HVAG Local Streets
	0.5 ESA/HVAG Collector Streets
• N_{HVAG}	Rural 2.8
	Urban 2.5

1.5.2 Subgrade Evaluation

Except where a mechanistic design approach is employed using Aust Roads Pavement Design Manual, 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).

The following factors must be considered in determining the design strength/stiffness of the subgrade:

(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.

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. Accordingly 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 Guideline D3 – Subsurface Drainage Design. If subsurface drainage is not to be 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 Design Moisture Content above the Optimum Moisture Content.

The calculation of the Design CBR shall be based on soaked conditions. All design assumptions and engineering judgments used to determine the Design CBR are to be included in the pavement design report.

i. Soaked conditions are to be adopted for the calculation of Design CBR and shall be based on a minimum of three(3) 5-day soaked CBR laboratory samples for each subgrade area compacted to 100 percent of standard maximum dry density

ii. The maximum spacing of test sites for field inspection pits is to be:
   - 100m for urban projects, minimum of two tests
   - 250m for rural projects, minimum of three tests

iii. Once each subgrade area has been classified according to its particular soil type and drainage assessed, the Design CBR for each subgrade area is computed by using the appropriate formulae as follows:

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

   Design CBR = 10th percentile of all individual CBRs, for five or more results

   = C – 1.3S

   Where C is the mean of all individual CBR tests, and

   S is the standard deviation of all values

Where the Design CBR, as determined above, is calculated to be less than 3, then the design engineer is to;

(a) Design and detail, by an industry recognised method acceptable to Council, the improvement measures required to improve the insitu sub-grade to CBR 3, and

(b) Design the pavement above the improved subgrade

Methods of improving the subgrade treatment, which are acceptable to Council, are available on an "*Information Note*" available on Council's Web page.

Where practicable, the design obtained by adopting the CBR from laboratory testing should be confirmed by testing existing road pavements near to the job site under equivalent conditions and displaying similar sub grades.

The pavement design report shall be prepared and certified by a suitably qualified and experienced professional engineer and include a summary of all laboratory and field test results and assumptions and/or calculations made in the assessment of subgrade support.

1.5.3 Environment

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 Aust Roads Pavement Design manual, ARRB-SR41, and to Aust Roads (formerly NAASRA) – Guide to Control of Moisture in Roads.

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 and salinity problems

(d) Relative permeability of pavement layers

(e) Whether shoulders are sealed or not

(f) Pavement type (boxed or full width)

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 of modulus) at the equilibrium moisture content likely to occur during the design life, i.e. 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.

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.

The pavement design report 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.

1.5.4 Pavement and Surfacing Materials

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 materials can be classified into essentially five categories or types:-

(a) Sprayed bituminous seals (chip seals)

(b) Asphaltic concrete and bituminous micro surfacing (cold overlay)

(c) Cement Concrete

(d) Concrete Segmental Pavers

(e) Clay Segmental Pavers

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

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

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

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

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

Concrete and clay segmental pavers shall satisfy the requirements of the Construction Specification for SEGMENTAL PAVING.

Bituminous micro surfacing (cold overlay) shall satisfy the requirements of the Construction Specification for BITUMINOUS MICRO SURFACING.

The use of sprayed bituminous seal (chip seal) is not acceptable wearing surface on any urban street, regardless of road hierarchy level classification, unless otherwise approved by Council.

1.5.5 Construction and Maintenance Considerations

The type of pavement, choice of base and sub base 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. Rural roads and streets shall be full-width construction unless otherwise approved

(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

1.6 Pavement Thickness Design

1.6.1 Pavement Structure - General

Unless otherwise approved, all pavement materials shall be supplied from commercial quarries where the material is to comply with the requirements of the Department of Main Roads Standard Specification MRS11.05 *Unbound Pavements.*

Current test results may be required to be submitted to Council to support the quality of material that is proposed to be used.

Where pavement materials from new quarries or gravel pits are proposed for use, current test results for CBR, Atterberg limits and material grading (as a minimum) shall be provided for Council approved.

Notwithstanding subgrade testing and subsequent pavement thickness design, the thickness of sub base and base layers shall not be less than the following:-

(a) Flexible pavement:

Design Traffic (ESA'S)	**Pavement Layer (mm)**	
	Sub-base	**Base**
<1 x 10^5	125	125
>1 x 10^5 < 2x 10^5	125	125
>2 x 10^5	150	150

(b) Rigid pavement:

Design Traffic (ESA'S)	**Pavement Layer (mm)**	
	Sub-base	**Base**
All values	100	150

The sub base layer shall extend a minimum of 300mm behind the back of any kerbing and/or channel.

The base and surfacing shall extend to the face of any kerbing and/or channel. Where the top surface of the sub base layer is below the level of the underside of the kerbing and/or channel, the base layer shall also extend a minimum of 300mm behind the rear face of the kerbing and/or channel.

For unkerbed roads, the sub base and base layers shall extend to at least to the nominated width of shoulder and shall provide for free drainage of both layers.

The pavement design engineer shall make specific allowance for traffic load concentrations within carpark areas (eg. entrances/exists). The minimum pavement thickness for carparks is to be 150mm.

The pavement design engineer shall make provision for pavement layer drainage on the assumption that during the service life of the pavement ingress of water will occur.

The use of any computer software (such as Circly) by the design engineer to determine the pavement structure will only be permitted where an alternative to a simple unbound or bound pavement is proposed.

1.6.2 Unbound Granular Flexible Pavements (Bituminous Surfaced)

The engineer shall refer to the relevant Reference document listed below, and adhere to the design approach detailed in the document, for the design of sealed flexible pavements:

<10^5 ESA's Aust Roads - Technical Report – *Pavement Design for Light Traffic – A Supplement to Aust Roads Pavement Design Guide AP-T36/06*

>1x10^5 ESA's Aust Roads – Pavement Design *"A Guide to the Structural Design of Road Pavements AP-G17/04".*

The design of the pavements is based on the traffic volumes (measured in ESA's) over the design life of the pavement.

Unbound granular flexible pavements designed in accordance with Aust Roads – *Pavement Design for Light Traffic – A Supplement to Aust Roads Pavement Design Guide AP-T36/06* shall use the 95% confidence limit curves for urban projects and 90% confidence limits for rural projects.

1.6.3 Flexible Pavements Containing Bound Layers (Bituminous Surfaced)

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 Aust Roads Pavement Design.

As an alternative to Aust Roads – *Pavement Design for Light Traffic – A Supplement to Aust Roads Pavement Design Guide AP-T36/06* for design traffic up to 10^5 ESA's, bound layers may be assumed equivalent to unbound layers of the same thickness, and the pavement designed in accordance with Aust Roads – *Pavement Design for Light Traffic – A Supplement to Aust Roads Pavement Design Guide AP-T36/06*, using 95% confidence limit curves.

1.6.4 Rigid Pavements

Rigid (concrete) pavements, with design traffic from 10^3 to 10^6 HVAG shall be designed in accordance with Aust Roads Pavement Design. *Pavement Design for Light Traffic – A Supplement to Aust Roads Pavement Design Guide AP-T36/06.*

Rigid (concrete) pavements for design traffic above 10^6 HVAG, the design shall be in accordance with Aust Roads Pavement Design, *A Guide to the Structural Design of Road Pavements, AP-G17/04.*

1.6.5 Concrete Segmental Pavements

Concrete segmental pavements with design traffic up to 10^6 ESA's and width estimated commercial vehicles exceeding 3T gross shall be designed in accordance with CMAA-T45.

For design traffic above 10^6 ESA's and with estimated commercial vehicles exceeding 3T gross the design shall be in accordance with Aust Roads Pavement Design, with the calculation of design traffic in terms of ESA's.

1.6.6 Clay Segmental Pavements

Clay segmental pavements with design traffic up to 10^6 ESA's shall be designed in accordance with Design Manual 1 – Clay Segmental Pavements.

For design traffic above 10^6 ESA's and up to 10^7 ESA's the design shall involve consideration of both Design Manual 1 – Clay Segmental Pavements and Aust Roads Pavement Design, with the thicker and more conservative design of each of the two methods adopted.

For design traffic above 10^7 ESA's, the pavement shall be designed in accordance with Aust Roads Pavement Design.

1.7 Surfacing Design

1.7.1 Choice of Surface Types

Except where the pavement is designed for concrete or segmental pave surfacing on urban access streets and places, the wearing surface shall be a bituminous wearing surface as indicated on the standard road hierarchy cross-sections as follows:-

(a) All street and roads (Urban areas)

- Primerseal, plus asphalt

(b) All streets and roads (Rural areas)

- Prime plus two coat chip seal

  Or

- Primerseal, plus asphalt

  Or

- Primerseal plus final seal

At all intersections and cul-de-sac turning circles on streets the design engineer shall take into account the vehicle braking and turning movements in the design and specification of the bituminous materials to be adopted.

Council may approve variations to these requirements in special circumstances. However to obtain the variation approval, the engineer must present a written developed case outlining the advantages to Council of the proposed change. Council reserves the right to refuse the request.

1.7.2 Sprayed Bituminous Seals (Chip Seals)

The design of sprayed bituminous (chip) seals, including primer seals, shall be in accordance with the Aust Roads Provisional Sprayed Seal Method – Revision 2000.

7mm primer seals shall be indicated on the Drawings below all asphalt surfacing. Where a 7mm primer seal is inappropriate, a 10mm primer seal shall be used in lieu.

Two-coat chip seals shall be double-double seals comprising a minimum of two coats binder and two costs of aggregate. The preferred seal types are:

1st coat	14mm
2nd coat	10mm

Single coat chip seals shall only be approved if asphaltic concrete is to be applied as the finished surface at a nominated later date.

1.7.3 Bituminous Micro surfacing (Cold Overlay)

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

1.7.4 Asphaltic Concrete

On urban and rural roads within design traffic up to 1 x 10^6 ESA's (except within industrial areas), the asphalt mix design shall be either a 'high-bitumen content' mix or Fine Gap Graded Asphalt (FGGA) mix in accordance with AUST ROADS Asphalt Guide and the Construction Specification for ASPHALTIC CONCRETE.

In industrial areas and on street and roads with design traffic greater than 1 x 10^6 ESA's, the asphalt mix design shall be a dense graded mix designed by the engineer in accordance with AUST ROADS Asphalt Guide and the Construction Specification for ASPHALTIC CONCRETE.

Notwithstanding the requirements of sub-clause 2.19(1) or (2), the engineer shall provide a minimum asphaltic compacted layer thickness as shown on the appropriate Council Standard Cross-section Drawing and not less than 50mm on intersections involving a collector street, or higher road hierarchy classification streets/roads.

A 7mm primer seal shall be indicated on the Drawings below all asphalt surfacing. Where a 7mm primer seal is considered inappropriate, a 10mm primer seal shall be indicated in lieu.

1.7.5 Segmental Pavers

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

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

The edges of all paving shall be designed to be constrained by either kerbing and/or channel, or by concrete edge strips.

1.8 Documentation

1.8.1 Design Criteria and Calculations

All drawings and documentation to be submitted to Council shall conform to the requirements of Council's Drawings and Documentation Guidelines D20. A copy of these Guidelines will be made available on request.

The Drawings shall clearly indicate the structure, material types and layer thicknesses of the proposed pavement and wearing surface.

All considerations, assumptions, subgrade test results, reference material and calculations shall be submitted with the pavement and wearing surface course design.

Failure to comply with Council's Drawings and Documentation Guidelines D20 may result in the drawing and/or documentation being returned to the engineer without consideration by Council.