

Technical Note 142

High Modulus Asphalt (EME2) Pavement Design

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1 Introduction

High modulus asphalt (EME) was developed in France over 30 years ago, and more recently has been introduced into other locations such as the United Kingdom and South Africa. It is primarily intended to reduce the thickness of full depth asphalt pavements whilst still providing sound pavement performance through a combination of high modulus, and superior fatigue, deformation and moisture resistance.

The name EME is derived from the French *enrobés à module élevé*, which translates to “asphalt with an elevated modulus,” or simply “high modulus asphalt.” The specific type of high modulus asphalt that is the subject of this Technical Note is based on the French EME Class 2 (EME2), which is the highest class of EME in the French standards (NF EN 13108-1 and NF P98-150-1). In France, EME2 is typically used in heavy duty pavements for high traffic roads.

This Technical Note is intended to facilitate the timely implementation of EME2 on Queensland Department of Transport and Main Roads (TMR) projects, and includes:

- A risk-based approach for implementation of EME2 in Queensland
- A summary of the mix design methodology and pilot technical specification
- An interim pavement design procedure
- References and key contacts for further information.

As this technology is rapidly evolving in Australia, it is recommended that this Technical Note be used in consultation with the Pavements, Research and Innovation Section of Engineering and Technology Branch of TMR, as detailed in Section 8 of this Technical Note.

2 Implementation of EME2 in Queensland

EME2 is being introduced into Queensland through a collaborative effort involving TMR, the Australian Road Research Board (ARRB), the Australian Asphalt Pavement Association (AAPA) and its members, and Brisbane City Council (BCC). In addition, the implementation into Queensland leverages off related projects by Austroads and other Australian road agencies.

EME2 has recently become available in Australia. The first Australian trial was undertaken in Brisbane in February 2014. This trial was a demonstration project on a local road which carries an average of about 30 heavy vehicles per day. Since then, this Technical Note and a pilot technical specification have been developed by TMR and ARRB to facilitate the implementation of EME2 in further project trials.

A risk-based approach to implementation is considered appropriate, where risks to TMR, contractors and other stakeholders are managed through the use of EME2 in trial situations with progressively increasing risk profiles. It is anticipated this will occur concurrently with an associated increase in local knowledge, capability and performance history. For example, use of EME2 on moderately trafficked roads, and on higher trafficked roads over shorter section lengths, is recommended prior to full scale use on major motorway-type projects for which TMR holds the performance risk. However, so as to promote implementation, it is intended that the progressively increasing risk profile of projects will not be unduly restricted, on the basis that the risk to TMR, contractors and other stakeholders is somewhat mitigated by existing international experience. Contractors should undertake their own project-specific suitability assessment for contracts that transfer performance risk to the Contractor.

Further advice on selecting suitable locations for project trials is available from the Pavements, Research and Innovation Section of Engineering and Technology Branch of TMR, as detailed in Section 8 of this Technical Note.

3 Asphalt mix design

A nationally consistent approach to mix design, including interim specification limits, has been developed (Austroads, 2014). This methodology is based on the French approach, which has been adapted to accommodate Australian test methods. The mix design methodology for EME2 is performance based, and comprises the following main steps:

1. Particle size (100% by mass passing the 19.0 mm sieve)
2. Richness modulus (conceptually similar to binder film thickness, and results in a minimum binder content)
3. Workability using gyratory compaction (maximum air void content after the specified number of gyrations)
4. Moisture resistance (stripping potential)
5. Permanent deformation resistance (wheel tracking)
6. Flexural modulus (4-point bending, although the indirect tensile modulus is also tested as an interim measure)
7. Fatigue resistance (4-point bending).

Further details on the test methods and interim specification limits are included in the EME2 pilot technical specification (PSTS107) and the related Austroads report (Austroads, 2014).

In addition to the mix design testing, EME2 requires the use of a binder that meets minimum and maximum limits for penetration and softening point, and minimum viscosity requirements. Two different classes of binder can be used in France. These are 15/25 and 10/20 penetration grade binders. The asphalt and bitumen industry in Australia currently supports the use of 15/25 grade binder, and this grade has been adopted in this Technical Note and the EME2 pilot technical specification (PSTS107).

When EME2 is being considered, it is recommended that the asphalt supplier be consulted to ensure a complying mix design exists, or can be developed in the available time, prior to project construction. The mix design procedure for EME2 may take significantly longer, and be more costly, than the design of conventional asphalt mixes.

4 EME2 pilot technical specification

A pilot technical specification, titled *PSTS107 High Modulus Asphalt (EME2)*, is available to facilitate the use of EME2 on TMR projects; PSTS107 applies to the construction of 14 mm nominal size EME2. The current pilot technical specification is written as a supplement to MRTS30 *Dense Graded and Open Graded Asphalt*. It will be updated to be a supplement to the new harmonised asphalt specification that is anticipated to replace MRTS30 in 2015.

The pilot technical specification includes provisions for mix designs undertaken using either the European or Australian test methods for wheel tracking, flexural modulus and fatigue. As there is limited knowledge with the use of the Australian test methods for EME2, including appropriate

specification limits, the current version of the pilot technical specification recommends these be limited to lower risk projects. For higher risk projects, use of the European test methods is recommended. In addition to the guidance provided in the pilot technical specification, selection of suitable project sites on the basis of project risk is recommended, as detailed in Section 2 of this Technical Note.

It is anticipated that the pilot technical specification will be developed further following increased local experience with its use, and as the results of trials become available.

5 Pavement design (interim method)

5.1 Introduction

The development of the interim pavement thickness design procedure is explored in more detail in (ARRB, 2015 forthcoming). The methodology is benchmarked against the French methodology, where two main approaches to pavement thickness design are used:

1. A catalogue of pavement structures based on subgrade support and traffic loading; and,
2. A mechanistic procedure which links mix characteristics of a specific mix (stiffness and fatigue) to pavement thickness.

Due to the currently limited local history of EME2 mixes and their long-term performance, a pavement thickness design procedure which links directly to mix characteristics is not currently available in Australia. Therefore, to enable the implementation of EME2 into Queensland, an interim approach has been developed which aligns with *Part 2: Pavement Structural Design of the Austroads Guide to Pavement Technology (AGPT02)* (Austroads, 2012) and the *TMR Pavement Design Supplement* (TMR, 2013). Benchmarking of the interim procedure with the French procedure has demonstrated that it results in realistic outcomes relative to existing heavy duty asphalt pavements. The interim method can also be readily applied within the current Austroads pavement design framework, and it allows direct comparison with conventional pavement options.

It is anticipated that future improvements in Australian pavement design procedures for asphalt pavements will lead to pavement designs being linked directly to mix-specific performance based testing undertaken during the mix design stage, which would be in-line with the French pavement design system. Until such time that sufficient information is available on EME2 mixes and performance in Australia, the procedure detailed in this Technical Note is recommended for use on TMR projects for which TMR holds the performance risk.

The French methodology also includes limits on layer thicknesses and subgrade support conditions. These too have been adapted for use in Queensland and are detailed in the following sections of this Technical Note.

5.2 Applicability

This Technical Note should be read in conjunction with *AGPT02* (Austroads, 2012) and the *Pavement Design Supplement* (TMR, 2013).

The design procedure detailed in this Technical Note is recommended for full depth asphalt pavements only. Consistent with the French pavement design catalogue, use of EME2 in pavements containing a cementitiously stabilised base or subbase is not recommended due to concerns regarding reflective cracking. Use of EME2 over a cementitiously treated improved layer (with unconfined compressive strength limited to 1.0 to 2.0 MPa at seven days) is acceptable.

5.3 Typical pavement structure

The typical structure of a full depth asphalt pavement with an EME2 base is as shown in Table 1.

Table 1 – Typical structure of full depth asphalt (FDA) pavement with EME2 base

Course	Description (typical) ¹
Surfacing	DG14HS, DG14HP, OG10, OG14 or SMA
Seal ^{1,2}	10 or 14 mm waterproofing seal with S4.5S binder
Intermediate	DG14HS or DG14HP
Base	EME2 according to PSTS107 with thickness determined by mechanistic design
Prime and seal ¹	Prime plus 10 or 14 mm nominal size Class 170 bitumen seal
Improved layer	Minimum 150 mm Type 2.3 unbound granular material that has been cementitiously treated (refer to Section 5.4 for further details).

1. Refer to the Pavement Design Supplement (TMR, 2013) for further guidance on the selection of asphalt and binder types in the surfacing and intermediate courses, the inclusion of the waterproofing seal, and priming and sealing the improved layer.
2. The waterproofing seal is typically not required under dense graded asphalt or stone mastic asphalt surfacing where the following minimum characteristic compaction standards are achieved in the surfacing and intermediate courses: 94.0% for SM14, and 93.0% for SM10, DG14HS and DG14HP.

5.4 Subgrade evaluation and improved layer

To enable adequate compaction and future pavement performance, the French pavement design procedures includes minimum support conditions below the EME2 base. To achieve this within the AGPT02 framework, the following minimum support provisions are recommended:

- Improved layer comprising a minimum 150 mm thick layer of Type 2.3 unbound granular material that is treated with a cementitious stabilising agent to achieve an unconfined compressive strength of 1.0 to 2.0 MPa at seven days (refer to PSTS103 *Working Platform*).
- An additional thickness of select fill or unbound granular material (if required), based on the bearing capacity of the underlying subgrade material, to increase the pavement support to an adequate level for long term pavement performance. Adequate support can be determined by using Equations 19 and 21 in *AGPT02* (Austroads, 2012), ensuring that the modulus achieved at the top of the improved layer is not less than 150 MPa.

For example, where the design CBR of the existing in situ subgrade material is 3%, application of Equations 19 and 21 in *AGPT02* (Austroads, 2012) indicates a select fill layer with minimum CBR 7% and thickness 170 mm below a 150 mm thick improved layer is necessary to achieve a modulus of 150 MPa at the top of the improved layer. Equation 19 results in a vertical modulus of 66 MPa for the top sublayer of select fill. Equation 21 then results in a vertical modulus for the top sublayer of the improved layer of 151 MPa.

Where the design CBR of the existing in situ subgrade material is 7% or more, a 150 mm thick improved layer is typically adequate without the need for any additional underlying selected material, unless required to address other issues such as expansive material or excess moisture.

While this approach provides for a minimum amount of pavement support, which is generally less than typically adopted in France, more substantial treatments are likely to have benefits in terms of overall

asphalt thickness reduction. Therefore, more substantial treatments should also be considered by the pavement designer in assessing project-specific alternatives.

To achieve adequate compaction of the asphalt layers, additional support may be necessary depending on the bearing capacity of lower layers at the time of construction. As a minimum, proof rolling of the improved layer and all other earthworks layers should be undertaken to confirm acceptable support has been achieved prior to the construction of overlying layers.

5.5 Asphalt design modulus and Poisson's ratio

For this interim pavement design methodology, the presumptive design moduli as detailed in Table 2 should be used. A Poisson's ratio of 0.4 is also applicable.

These moduli values are based on an analysis of indirect tensile stiffness modulus test results from:

- currently available Australian EME2 mixes; and,
- a French EME2 mix, that was produced in France and tested in Australia.

Table 2 – Presumptive values for elastic characterisation of EME2 at a WMAPT of 32°C.

Asphalt Mix Type	Binder Type	Volume of binder (%)	Asphalt modulus at heavy vehicle operating speed (MPa)			
			10 km/h	30 km/h	50 km/h	80 km/h
EME2	EME binder (15/25 pen)	13.5	2000	3000	3600	4200

For other WMAPTs, Equation Q6.1 of the *Pavement Design Supplement* (TMR, 2013) is considered to be acceptable for temperature correction of these presumptive moduli.

5.6 Layer thickness limits

In accordance with the pilot technical specification, the target thickness of each individual compacted layer of EME2 should be between 70 and 130 mm.

5.7 Thickness design

The interim approach to thickness design is as per the existing mechanistic design procedures for full depth asphalt pavements, as detailed in Section 9 of *AGPT02* (Austroads, 2012) and the *Pavement Design Supplement* (TMR, 2013).

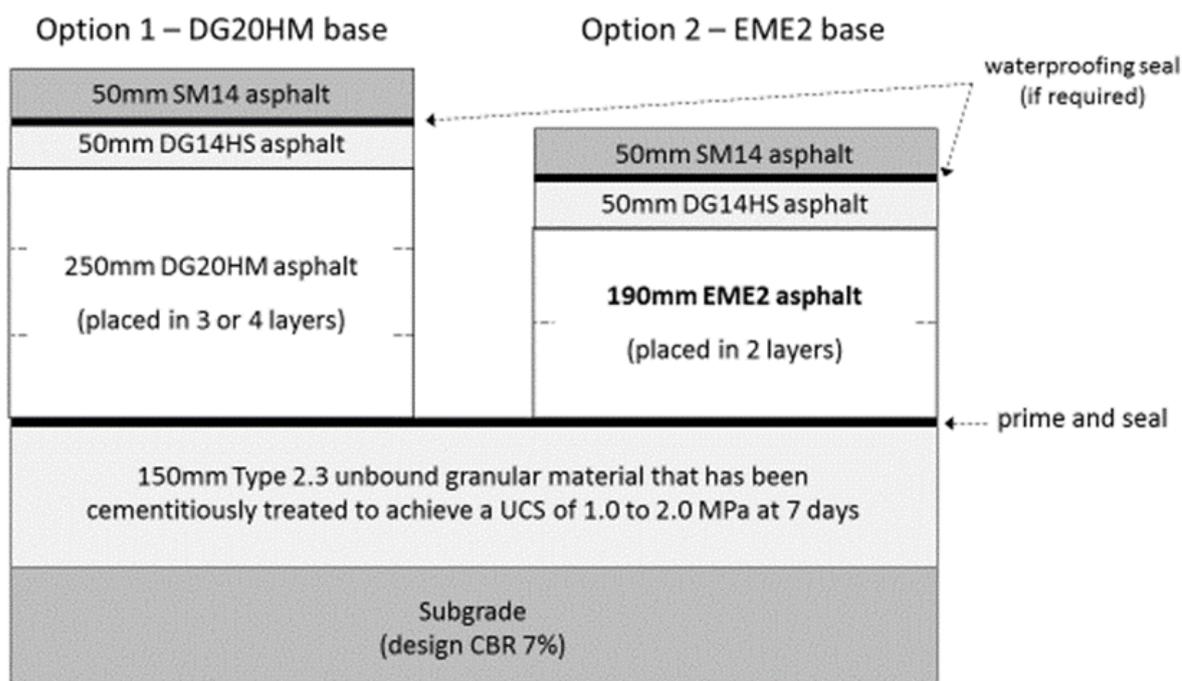
6 Example EME2 pavement design

The following example compares a full depth asphalt pavement comprising EME2 base asphalt with a conventional design comprising DG20HM (with Class 600 bitumen). The design inputs in Table 3 are based on a typical heavily trafficked road in South East Queensland. Materials were modelled in accordance with the presumptive values detailed in the *Pavement Design Supplement* (TMR, 2013) and this Technical Note. Results are shown in Figure 1.

Table 3 – Design inputs

Site conditions	Value	Design parameters	Value
WMAPT (°C)	32	Design traffic (ESA)	1.1×10^8
Heavy vehicle speed (km/h)	80	SAR5/ESA	1.1
Subgrade design CBR (%)	7	SAR7/ESA	1.6
Subgrade expansive nature	low	Project reliability (%)	95

Figure 1 – Example pavement design results



Notes:

1. Base asphalt thickness includes 10 mm construction tolerance
2. Project-specific assessment is necessary to guide the decision on inclusion of the waterproofing seal, and priming and sealing the improved layer.

7 Further information

Further information on EME mix design, pavement design and implementation in Australia is included in the references listed in Section 9 of this Technical Note. This list includes currently available references, and known imminently pending references. In addition to these, further research and development is currently underway in the following projects:

- Cost-effective design of thick asphalt pavements: high modulus asphalt implementation (project P9 in TMR/ARRB research program)
- Characterisation of asphalt fatigue at Queensland Pavement Temperatures (project P10 in TMR/ARRB research program)
- High Modulus High Fatigue Asphalt (EME) Technology Transfer (project TT1908 in Austroads pavement technology program)
- Improved Design Procedures for Asphalt Pavements (project TT1826 in Austroads pavement technology program)
- EME2 mix design development by Australian asphalt companies.

8 Contacts

As development of the technical specification and pavement design procedure is ongoing, it is recommended that anyone considering the use of EME2 should first contact the following TMR representatives to obtain an update on any recent developments.

Technical Specification: Jason Jones, Principal Engineer (Asphalt and Surfacing)

Email: jason.d.jones@tmr.qld.gov.au

Pavement Design: Peter Bryant, Principal Engineer (Pavement Design)

Email: peter.n.bryant@tmr.qld.gov.au

9 References

ARRB 2015, forthcoming, Cost-effective design of thick asphalt pavements: high modulus asphalt implementation, L Petho, contract report.

Austrroads 2012, Guide to pavement technology: part 2: pavement structural design, 3rd edn, AGPT02-12, Austrroads, Sydney, NSW.

Austrroads 2013, EME2 technology transfer to Australia: an explorative study, AP-T249/13, Austrroads, Sydney, NSW.

Austrroads 2014, High modulus high fatigue resistance asphalt (EME) technology transfer, AP-T283/14, Austrroads, Sydney, NSW.

Department of Transport and Main Roads 2013, Pavement design supplement: supplement to 'part 2: pavement structural design' of the Austrroads guide to pavement technology, TMR, Brisbane, Qld.

NF EN 13108-1:2007, European Standard: Bituminous mixtures - Material specifications - Part 1: Asphalt Concrete, May 2006, European Committee for Standardization and Association Francaise de Normalisation (AFNOR).

NF P98-150-1:2010, Bituminous asphalts: Placement of pavement bases, binder and wearing courses: part 1: hot-mix asphalts: constituents, formulation, manufacturing, transportation, placement and site inspection (French language), Association Francaise de Normalisation (AFNOR).

PSTS107 High Modulus Asphalt (EME2), Project Specific Technical Specification, Transport and Main Roads Specifications, TMR, Brisbane, Qld.

