Transport Roads & Maritime Services

PTD 2015/001

Foamed Bitumen Stabilisation

Summary:	Audience:
This Technical Direction sets out requirements for the stabilisation of pavement materials using foamed bitumen and lime as the binders.	• Engineers • Work supervisors • Surveillance officers

Introduction

Foamed bitumen stabilisation (FBS) involves insitu or plant mix stabilisation of pavement materials with bitumen as the primary binder. The process is used to improve the strength of granular materials while retaining a flexible pavement. The foamed bitumen content generally ranges from 3% to 4% by mass of the material being bound. Lime is added as a secondary binder to provide initial strength, improve the strength of the mix and help disperse bitumen through the mix. Secondary binders other than lime are not permissible.

In 2011, Austroads published the following two reports on foamed bitumen stabilisation:

- AP-T178-11 Review of Foamed Bitumen Stabilisation Mix Design Methods (Austroads, 2011a).
- AP-T188-11 Review of Structural Design Procedures for Foamed Bitumen Pavements (Austroads, 2011b).

Appendix A of the Report AP-T178-11 (Austroads, 2011a) contains recommendations for mix design and Appendix C of the Report AP-T188-11 (Austroads, 2011b) contains an interim procedure for structural design of foamed bitumen stabilised pavements. This technical direction is issued to clarify, add to, or modify the requirements of Appendix A of the Report AP-T178-11 (Austroads, 2011a) and Appendix C of the Report AP-T188-11 (Austroads, 2011b). FBS pavements are to be designed in accordance with these Austroads report appendices in conjunction with the supplementary information in this technical direction.

Suitability assessment and design

Not all materials are suitable for FBS as the process is sensitive to material grading and plasticity index. A suitability assessment is to be undertaken prior to mix and pavement design.

Approvals:

Owner:	Principal Engineer, Pavements & Geotechnical	Review Date:	
Authorised by:	Chris Harrison	Effective Date:	17 March 2015

Each pavement design requires a mix design to be undertaken to determine the binder content required to provide the pavement material modulus that is used in the pavement structural design. During the investigation and design phase, allowance must be made for the collection of sufficient pavement material and the time required to undertake a laboratory mix design (*Refer to Sampling and Collection Section*).

The suitability assessment and design process is illustrated in Figure 1.

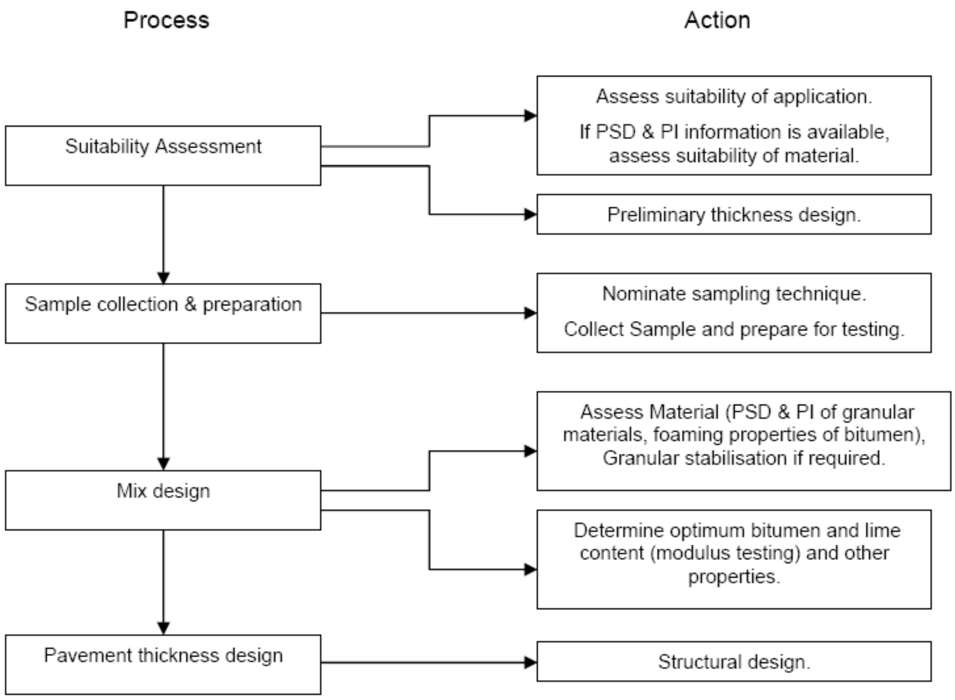

Figure 1 Foamed bitumen stabilisation suitability assessment and design process

Suitability assessment

Suitability of the application

Foamed bitumen stabilisation is suitable for use in the following situations:

- In a weak granular pavement to improve strength.
- Rehabilitation of previously cementitious stabilised pavements where the addition of further cementitious binder is not feasible.
- An alternative to full depth asphalt in low to moderate trafficked roads.
- Improving a pavement material's resistance to moisture effects.

Consider the following factors before selecting the foamed bitumen stabilisation option:

- Cost – Depending on binder content the initial cost is higher than cementitious stabilisation but lower than asphalt.
- Pavement design for heavily trafficked roads – For heavily trafficked roads a very thick pavement is required. Incorporating an asphalt overlay will reduce the thickness of the FBS course.

- Utility depth – As a thick pavement is required for heavily trafficked roads, utility depth should be considered during the pavement option selection. The current design model results in a thicker pavement when compared to asphalt.
- Vibration – For the compaction of insitu stabilised pavements, heavy vibratory rollers are required for deep lifts. In areas where structures are adjacent to the pavement, vibratory compaction may not be acceptable.
- Moisture – Where the insitu moisture content of the unstabilised pavement course is greater than 70% of the unstabilised material optimum moisture content (OMC), compaction of the FBS material is difficult and the specified compaction limits may not be achievable.
- Plasticity and particle size distribution (PSD) of the granular material - There are requirements for maximum Plasticity and PSD of the material to be stabilised in the mix design section of this Technical Direction.
- Existing bound pavement – The preferred practice for stabilisation of an existing bound layer is to pre-pulverise the full thickness of the bound layer to prevent reflective cracking in the FBS course. If the thickness of the FBS course is less than the pulverised depth, a suitable work practice is required to ensure full compaction of the pulverised material.

Preliminary thickness design

Carry out a preliminary thickness design to assess the feasibility of the foamed bitumen stabilisation option and to determine that it meets the specified thickness limits in the specification.

Carry out the preliminary thickness design in accordance with Appendix C (Interim Procedure) of the Austroads Report AP-T188-11 (Austroads, 2011b). In the interim procedure the foamed bitumen stabilised layer is modelled as a bound pavement layer using the Austroads asphalt fatigue relationship. Prior to determining an appropriate design modulus by laboratory testing adopt the presumptive parameters in Table 1 for preliminary mechanistic thickness design.

Table 1: Parameters for FBS layer preliminary thickness design

Parameter	FBS material
Sublayering	No
Design Modulus of FBS material (E_v)	2000 MPa
Lower Interface (Lower I/F)	Rough
Ratio of vertical and horizontal modulus of FBS material (E_v / E_h)	1.0
Poisson’s ratio of FBS material	0.4
Volume of bitumen binder (%)	7 (Assuming 3.5% bitumen by mass)

Sample collection and preparation

The following methods are available for sample collection of insitu materials for insitu stabilisation:

- Cold planer (milling by profiler or stabiliser/reclaimer) – Full scale sampling is ideal but expensive, requires significant pavement replacement at the time of sampling and is generally limited to one location.

- Skidsteer mounted rotomill – Suitable for bound material and smaller samples. Multiple sampling locations are feasible. The depth of sampling is limited by the specific machine's characteristics (typically up to 200 mm).
- Trencher – Suitable for bound material. Full pavement depths and multiple sample locations are feasible.
- Backhoe – Suitable for unbound material.

The most cost effective option for bound material sampling is by skidsteer mounted rotomill and for unbound material sampling by backhoe. The method selected must be capable of sampling to the full depth of the proposed stabilisation thickness.

Sample collection should be carried out in accordance with Appendix A.2 of Austroads Report AP-T178-11 (Austroads, 2011a). A minimum of 120 kg of material is required for mix design in accordance with RMS Test Method T154 (RMS, 2013d). An additional 300 kg of materials is required when rut testing is required.

At each sampling location the following sampling and testing is also required to determine other material properties for the pavement structural design:

- Thickness of layers.
- Description of material types.
- Moisture content of the layers.
- Grading and plasticity of the layer/s proposed for stabilisation.
- Insitu CBR of subgrade.
- Laboratory CBR of the Subgrade.

For plant mix stabilisation, if a quarry material is used the sample should be pre-treated in accordance with RMS Specification 3051 (RMS, 2011).

For insitu stabilisation the sampling process is assumed to imitate any breakdown of material during construction and no pretreatment is required for the mix design.

Mix design

Material assessment

Bitumen type must be in accordance with RMS Specification R76 (RMS, 2013a).

Determine the bitumen foaming properties in a laboratory in accordance with RMS Test Method T153 (RMS, 2013c).

Foamed bitumen binder must comply with the following requirements:

- minimum Expansion Ratio (ER) of 10.
- minimum Half-Life (HL) of 20 seconds.

The addition of a foaming agent is permissible to enable foaming properties to be achieved. Where a bitumen foaming additive is used it must comply with RMS Specification 3255 (RMS, 2013e).

The particle size distribution (PSD) requirements of the 'Material To Be Bound' are included in Table 2. A PSD outside the envelope in Table 2 may be accepted if rut testing shows satisfactory performance in addition to the modulus of foamed bitumen stabilised material complying with specified limits.

Table 2: Particle Size Distribution

Sieve Size (mm)	**Percentage passing**	
	Initial daily traffic on opening < 1000 ESA	**Initial daily traffic on opening > 1000 ESA**
26.5	73 – 100	100
19.5	64 – 100	80 – 100
9.5	44 – 75	55 - 90
4.75	29 – 55	40 – 70
2.36	23 – 45	30 – 55
1.18	18 – 38	22 – 45
0.6	14 – 31	16 – 35
0.425	12 – 29	12 – 30
0.3	10 – 27	10 – 24
0.15	8 – 24	8 – 19
0.075	5 – 20	5 – 15

Clause A.4.2 of the Austroads mix design report (Austroads, 2011a) includes a recommendation for the maximum acceptable plasticity index of the granular material. If lime is proposed to reduce the material's plasticity before foamed bitumen stabilisation, laboratory testing should be conducted to assess the required lime content and mellowing/curing time.

Consult with RMS Road Pavement & Geotechnical Engineering, Flexible Pavement Unit for trial mix combinations for modulus testing. Generally, 3 sets of trial mixes are prepared. The starting point for trial mixes is based on Table A2 of Austroads Report AP-T178-11 (Austroads, 2011a). In Table A2 the bitumen content is based on the PSD while lime content is based on the plasticity index. Where the starting point for bitumen is indicated at the upper (4%) or lower (2%) limits of the table, treat these as upper and lower binder application limits (ie if 4% is indicated as starting point, test mixes at 3%, 3.5% and 4% of bitumen).

Specification R76 (RMS, 2013a) permits the incorporation of the bituminous wearing surface up to 80 mm thick onto the FBS course. Where the existing wearing course is to be incorporated into the FBS layer, include the material for the mix design. The sampled wearing course is to be crushed and incorporated into the laboratory mix in the same proportion (by mass) as will occur during field mixing.

Specification R76 (RMS, 2013a) permits the incorporation of patches into the FBS material if specified in Annexure A. Prior to specifying to include patches in the Annexure, validate the proposed mix design with the inclusion of the patch material using the same binder contents as determined for the non-patched area. If the mix including the patched material meets the specified modulus requirement then patch material can be included in the FBS and nominated as such in R76 Annexure A. Where it does not meet the specified modulus requirement patches must be removed and replaced with material specified in specification 3051.

Prepare trial mixes, test specimens and conduct modulus testing in accordance with RMS Test Method T154 (RMS, 2013d) to determine the average resilient modulus. Plot the average resilient modulus against binder content and determine the design bitumen application rate (by mass) that provides the required minimum modulus value (both initial and soaked) and retained modulus ratio specified in Table 3. Where the modulus values do not satisfy the specified modulus limits, seek advice from RMS Road Pavement & Geotechnical Engineering, Flexible Pavement Unit on interpreting the results.

Table 3: Minimum modulus values and retained modulus ratio

Average Daily ESA's in Design Lane in Year of Opening	Initial Modulus (MPa)	Soaked Modulus (MPa)	Minimum1 Retained Modulus Ratio
< 100	500	1500	40 %
100 – 1000	700	1800	45 %
> 1000	700	2000	50 %
Note: 1. Ratio of soaked to cured modulus expressed as a percentage.			

Other properties

In addition to the modulus testing, consider rut resistance testing for high risk projects or where the PSD of the material to be bound is outside the specified limits. Consult with RMS Road Pavement & Geotechnical Engineering, Flexible Pavement Unit for rut testing requirement and interpretation of results.

For wet environments, such as flood inundation areas, the designer should consider additional testing of the material, including permeability and capillary rise.

Pavement thickness design

The structural design procedure for the pavement thickness design is similar to the preliminary thickness design except that:

- The design modulus (Ev) is the average soaked resilient modulus corresponding to the design bitumen application rate determined in accordance with Test Method T154 (RMS, 2013d) and adjusted for temperature and rate of loading. Follow the steps in Appendix C3 of the Austroads Report AP-T188-11 (Austroads, 2011b) to adjust for temperature and rate of loading.
- Where the adjusted average soaked resilient modulus value exceeds 2500 MPa, the design modulus is to be limited to 2500 MPa.
- The percentage by volume of bitumen binder (Vb) for use in the fatigue equation formula for asphalt is the volume (%) used to determine the modulus for the selected mix design. This volume percent is reported as Vb% in the test results of RMS T154 (RMS, 2013d).
- Refer to RMS Supplement to Austroads Pavement Design Guide Part 2 (RMS, 2013g) for material properties and design requirements for other layers in the pavement.

Construction process and conformance

General

Construction must comply with the requirements of Specification R76 (RMS, 2013a). The design, target and actual application rates of binders and associated information and calculations are to be recorded in RMS Form No. 5113 (RMS, 2013f).

Existing geotextile seals

Remove any geotextile seal from the existing pavement before the foamed bitumen stabilisation.

Incorporating patches in the insitu stabilisation

Where specified in Annexure A of Specification R76 (RMS, 2013a) asphalt and cementitious patches can be incorporated in the FBS. Patches may require pre-pulverisation for homogenous mixing into the FBS.

Placing of plant mixed stabilised materials

It is recommended that the plant mixed material be placed in one layer. Approval may be obtained to place multiple layers where an effective method of bonding the layers can be demonstrated by tackcoating or other suitable means.

Compaction assessment

Relative compaction assessment relates to the laboratory reference density of the material collected in the field. T he reference density is affected by any delay in sample compaction, temperature change or moisture content change. Experience shows that the laboratory reference density of foamed bitumen stabilised material, when assessed using the standard compaction procedure, is usually lower than that achieved by field compaction. As a result the relative compaction results are inflated and values in the range of 110% to 115% are not uncommon. When standard compaction is used to prepare relative compaction samples the minimum relative compaction limit has been increased in the specification to 106% for pavement thickness ≤ 250 mm and 104% for pavement thickness > 250 mm.

The addition of hot bitumen acts as a lubricating agent that effectively reduces the optimum moisture content of the FBS mix. When the pavement material’s moisture content prior to FBS is > 70% of the unbound pavement material’s optimum moisture content, difficulties in achieving the specified level of compaction is likely. An additional construction process to dry the material prior to FBS may be required to prevent under compaction. To dry the material it may be ripped and reworked or if imported material is added the material may be delivered at low moisture content. Care must be taken to prevent segregation of dry imported material.

Work health and safety issues

Contact with hot bitumen can cause severe burns. Follow the relevant in-house procedures and SWMS for working with hot bitumen.

Field testing to determine the bitumen half-life and expansion ratio of bitumen must be carried out to demonstrate compliance with the specification requirements. Requirements for the stabiliser mounted test jet are included in RMS Work Health and Safety Specification G22 (RMS, 2013b). The location of the test jet must be in a safe location and operated by a competent person in line with the relevant SWMS. Sampling foamed bitumen for testing purposes at any location other than the specified test jet is not permitted.

Surfacing requirements

A sprayed seal or asphalt surfacing is required on foamed bitumen stabilised material.

For sprayed seals placed on FBS material the following requirements are to be applied:

- For the initial seal, a 14 mm single/single seal with 7 mm scatter coat is applied in accordance with R106 with a maximum ball penetration result of 3 mm prior to sealing.
- The initial seal should contain a residual binder application rate of approximately 1.3 L/m² and use a C240 binder (C170 binder may be appropriate in cold areas).
- Braking, parking or accelerating on a fresh seal should be avoided and vehicles stopped at traffic control points should have their wheels located between wheel paths and on the shoulder. In hot weather where traffic volumes are high the location of the traffic control point should be moved every 2 hours.

- The amount of cutter in a primerseal is to be minimised to prevent softening of the FBS layer. Cutter content is to be limited to 2% in summer and 5% in winter.

For asphalt over FBS material the following requirements are to be applied:

- Where asphalt is placed as a structural layer, its thickness must be a minimum of 100 mm.
- If there is delay in applying the asphalt course, a sprayed seal should be applied to the surface to protect the FBS material and to provide waterproofing.
- Asphalt can be placed over the FBS material after a minimum of one week of curing in summer and two weeks in winter after construction. Prior to placing of the asphalt apply a 7mm sprayed seal.

References

RMS (2006) *Sprayed Bituminous Surfacing (with Bitumen Emulsion)* Specification R111, Ed 2, Rev. 0, Roads and Maritime Services, North Sydney, NSW.

RMS (2011) *Granular Base and Subbase Materials for Surfaced Road Pavements* Specification 3051, Ed 6, Rev. 2, Roads and Traffic Authority, North Sydney, NSW.

Austroads (2011a) *Review of Foamed Bitumen Stabilisation Mix Design Methods* Report AP-T178-11, Sydney, NSW.

Austroads (2011b) *Review of Structural Design Procedures for Foamed Bitumen Pavements* Report AP-T188-11, Sydney, NSW.

RMS (2013a) *Insitu Pavement Stabilisation using Foamed Bitumen* Specification R76, Ed 1, Rev. 0, Roads and Maritime Services, North Sydney, NSW.

RMS (2013b) *Work Health and Safety (Construction and Maintenance Works)* Specification G22, Ed 5, Rev. 3, Roads and Maritime Services, North Sydney, NSW.

RMS (2013c) *The Half-life and Expansion Ratio of Foamed Bitumen* Test Method T153, Ed 1, Rev. 0, Roads and Maritime Services, North Sydney, NSW.

RMS (2013d) *Resilient Modulus of Road Construction Materials Stabilised by Foamed Bitumen (blended in the laboratory)* Test Method T154, Ed 1, Rev. 0, Roads and Maritime Services, North Sydney, NSW.

RMS (2013e) *Bitumen Foaming Additive for Stabilisation* Specification 3255, Ed 1, Rev 0, June 2013, Roads and Maritime Services, North Sydney, NSW.

RMS (2013f) Foamed Bitumen Stabilisation Record Sheet for Binder Application Rates RMS Form No. 5113, December 2013, Roads and Maritime Services, North Sydney, NSW.

RMS (2013g) RMS Supplement to Austroads Guide to Pavement Technology Part 2: Pavement Structural Design Version 2.1, Roads and Maritime Services, North Sydney, NSW.