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INTRODUCTION

This Annexure is intended to help keep practitioners abreast of new developments in sprayed sealing. The processes and treatments that will be included in this section, from time to time, have either recently become available or will do so shortly.

The purpose is to provide some understanding of possible new surfacing treatment options and how these might form part of an overall pavement management strategy. It is intended to be a practical guide to assist in the assessment of the treatments. It addresses the selection, design, and all aspects of field practice, and should generally be read in conjunction with the appropriate section of the Guide.

The processes discussed in this section are often the result of overseas development and successful usage, sometimes over many years. The introduction and on-going development of these processes and treatments to meet Australian needs, may involve considerable trialing and adaptation to local conditions.

Inclusion of processes and treatments in this section of the Guide in no way constitutes an endorsement by the Authority of such processes and treatments. Reasons for this may include:

- a need for further trialing and performance evaluation
- lack of adequate long term performance evaluation (particularly under different conditions)
- processes and/or treatments being of a proprietary nature and available through a sole supplier.

While every effort is made to keep this Guide up to date, the Authority takes no responsibility for the application of information in this section. The selection and application of treatments included in this section should be based on professional evaluation by experienced road practitioners to determine appropriateness.

NOTE:
It is intended that once the Authority becomes confident in the soundness of the technology involved in each of these processes / treatments and the long term benefits as a maintenance and/or construction treatment, details of the process / treatment will be included in the main body of this Guide.
FIBRE REINFORCED
SPRAYED SEALING
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INTRODUCTION

This Section has been written to explain Fibre Reinforced Bituminous Surfacing, including operational procedures and design.

It provides supplementary information to be used in conjunction with both quality control and quality assurance specifications.

**Note:** This following text in no way constitutes an endorsement by the Authority.

**What is a Fibre Reinforced Sprayed Seal (FRSS)?**

A FRSS is a glass fibre reinforced bituminous treatment for cracked pavements. It was originally developed in Britain and has been used extensively throughout Europe in applications ranging from car-parks to major road and airport pavements.

It is a sprayed sealing treatment consisting of two coats of a polymer modified bituminous emulsion, between which is applied a layer of glass fibre strands. The fibres are applied randomly to form a mat that resists reflective cracking. Finally, a layer of aggregate is spread and rolled in the normal manner. Under normal conditions, the surface may be opened to traffic immediately, as with conventional sprayed seals.

As a wearing course, a FRSS provides a surfacing treatment which is resistant to cracking, i.e. a strain alleviating membrane (SAM). It may also be used as a strain alleviating membrane interlayer (SAMI) under other wearing courses.

A FRSS system is marketed in Australia by Pioneer Road Services as the "Fibredec system" and has been adapted for local conditions and materials.

**Benefits**

The main benefits of a FRSS include the following:

- a cost effective treatment for cracked pavements (cheaper than geotextiles and has potential to last longer than traditional maintenance methods which do not involve strain alleviation)
- may be laid at near ambient temperature, and as such has both operational and environmental advantages
- the use of emulsion means that the treatment may be laid throughout the year, even under cool and damp conditions.

A FRSS treatment has simplicity of application which provides other benefits:

- the treatment is completed in one pass minimising disruption to traffic and inconvenience to road users
- traffic may use the new surface immediately after rolling.

**SELECTION AND USE OF A FRSS**

**General**

A FRSS is a sealing treatment specifically designed to control cracking. It provides strain attenuation in the horizontal direction whilst being capable of transferring loads in the vertical direction. As such, it is suitable for a wide range of applications, including the following:

- surfacing of cracked pavement
- as a SAMI between flexible layers of a pavement
- sealing and reinforcing of sub-layers
- as an in-situ blanket strengthening layer.

These applications are illustrated in Figures F1 (a) to (d) - inclusive.
Figure F1 Various FRSS Applications
Functional Aspects of Selection

A FRSS may be used on asphalt pavements that are old and crazed, and particularly when the asphalt is brittle. It may even be used on severely cracked pavements.

It provides an effective waterproof seal, and may be used where geotextile sealing is not appropriate.

Advantages

A FRSS has the following advantages:

- twice as fast as geotextile sealing being a one pass operation and requires only half the amount of fibre
- no jointing required
- curved alignments require no extra effort
- no tack coat required
- not subject to risk of fabric debonding
- can be applied by hand spray to small areas
- can be used in windy conditions which cause difficulties with geotextiles
- typically, the residual binder is $1.8 \text{ L/m}^2$ for a FRSS compared to $2.6 \text{ L/m}^2$ for a geotextile.

MATERIALS

Binder

The binder is a specially formulated proprietary cationic bitumen emulsion modified with polymer, with increased viscosity and ductility.

The residual binder content of the emulsion should be a minimum of 67% by mass.

Fibres

The fibres are supplied as continuous glass fibre coils which are chopped into the required lengths for spreading. Typical cut lengths of fibre strands used are 30 and 60 mm, but 90 mm lengths may be used to suit the size of cracks in the pavement.

Mineral Aggregate

The aggregate should consist of crushed rock, metallurgical slag or crushed gravel, which is uniform in quality and particle size distribution. It should be hard, angular, durable, and free from deleterious material.

The aggregate should be lightly precoated with a diluted emulsion as recommended by the supplier. Precoating of the aggregate should be carried out one to two days before use.

Design of a FRSS Treatment

The design for a FRSS treatment should be based on conventional sprayed seal design, plus the appropriate allowance for binder required to coat the glass fibres.

As FRSS is a proprietary process, the Contractor is responsible for ensuring the design meets specified performance requirements.

A FRSS wearing surface should have the same physical and performance qualities as a corresponding conventional sprayed seal (in addition to the strain alleviating characteristics).

Care should be taken when designing FRSS treatments for use as a SAMI. If binder application rates are high, this may cause shoving or early fatigue failure of the asphalt layer.

SURFACE PREPARATION

Cleaning

The existing pavement should be swept clean using a rotary road broom, to remove any loose stones, dirt and foreign matter. Sweeping should extend at least 300 mm beyond the edge of the area to be surfaced. Any foreign matter adhering to the pavement, and not swept off by the broom, should be removed by other means.

Any areas affected by minor oil contamination should be cleaned by an
approved method. Where the surface is significantly affected by oil, rectification of the defects will need to be undertaken as described below.

Extruded thermo-plastic markings and reflective markers should be removed or protected for re-use before surfacing commences.

**Pavement Watering**

All new work must be pre-dampened using a water tanker immediately before spraying. There should be no apparent water flowing or ponding in front of the sprayer.

The watering of the surface should leave the pavement damp assisting the spreading of the emulsion. It also cools hot pavement surfaces to prevent premature breaking of the emulsion.

**Rectification of Surface Defects**

As poor pavement and surface repairs will adversely affect the performance of the surfacing, the following actions should be taken as appropriate:

- If after cleaning, the surface is soft or has ravelled, the affected area should be removed and reinstated
- Fresh coldmix or temporary patches should be removed and the pavement reinstated.

**Protection of Services**

Precautions should be taken to prevent binder being sprayed onto kerb and gutters, service covers, etc., by using plastic sheeting or paper as a mask.

All plant and equipment used in the performance of the work should be provided and maintained in good working condition by the Contractor.

**Sprayer**

The sprayer is a specially built unit incorporating a patented two-spray bar system for the emulsion application and an intermediate glass fibre distribution manifold.

Each spray bar applies half the binder.

The fibre is supplied in a continuous rolls which are carried on the sprayer (see Photograph F1). The continuous fibres are chopped into the required lengths by rotating blades, and then blown down onto the pavement by axial fans to form a random mat arrangement.

Both the length of the fibre strands and the rate at which these are spread by the fans may be varied to provide the required density of fibre.

The sprayer is fitted with a skirt to ensure the formation of the random pattern is not adversely effected on windy days.

The spraying width is controlled from the sprayer cab. The maximum spraying width is 2.5 m but can be as narrow as 0.15 m

**FIELD OPERATIONS**

**General**

A FRSS has all the advantages normally associated with a sprayed sealing activity, especially in terms of speed of operation and minimal disruption to traffic.

**Weather Limitations**

A FRSS may be used on a dry or damp surface, but should not be laid on a wet surface.

If pavement temperatures are very high, the emulsion can tend to break before the aggregate is spread, resulting in poor adhesion. Dampening of the surface may assist by lowering the pavement temperature.
Purpose-built FRSS Sprayer

Photograph F1

Spraying Operation

Photograph F2

Fibres Spread on Sprayed Binder

Photograph F3
TABLE F1
TYPICAL FRSS APPLICATION RATES

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<tr>
<th>Materials</th>
<th>Nominal Size Aggregate</th>
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<tr>
<td></td>
<td>7 mm</td>
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<tr>
<td>Residual Binder</td>
<td>1.2 L/m²</td>
</tr>
<tr>
<td>Fibres</td>
<td>60-80 g/m²</td>
</tr>
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</table>

Sealing should only be undertaken when the pavement temperature is at least 10°C and rising. However, longer periods of initial traffic speed control are required at low pavement temperatures.

Binder Coats

The binder is sprayed in two equal applications at a temperature of 80°C to 90°C. The first coat of binder is sprayed directly onto the cleaned surface. The second coat being sprayed in the same operation, immediately after the spreading of the fibres (see Photographs F2 and F3).

The total binder application rates depend on the nominal aggregate size, the type of surface on which the FRSS is being laid, and the length of the fibre strands.

The additional emulsion required to coat the fibre is between 0.3 and 0.5 L/m². Typical residual binder application rates are shown in Table F1.

A wet edge of approximately 50 mm should be left uncovered at the end of each run for overlapping of the next run. Protective paper should be laid transversely across the pavement at the start and finish of the sprayer run. It should be removed before commencing aggregate spreading.

Spreading of Fibres

The fibres are cut to the required length and blown by fans onto the first coat of emulsion in a random, but uniformly dispersed pattern. The spraying of the second coat of emulsion, in the same pass, produces a glass fibre sandwich within the binder.

The lengths of the fibre strands, typically 30 mm and 60 mm, are determined by the extent of the cracking. In some circumstances special applications, such as a 30 mm / 90 mm fibre blend, may be appropriate.

The rate of application of the fibre strands is also variable to meet the design requirements. Typical application rates for the fibres are also shown in Table F1.

Aggregate Spreading

Aggregate spreading should generally commence immediately after spraying has started, with spreading trucks operating close to the sprayer. Some delay may be necessary with 14 mm aggregate.

The aggregate is spread at a rate to give a uniform single stone thickness of aggregate with the particles in contact.

A scatter coat of 5 mm or 7 mm aggregate may be required for aggregates of nominal size 10 mm or larger, to prevent the aggregate from rolling and being dislodged as the seal gains strength during the first few days of its life.
Rolling

Rolling is carried out immediately after spreading of the aggregate. Normally, 2 or 3 passes of a pneumatic-tyred roller is sufficient.

Traffic Time

The traffic time for a new FRSS treatment (i.e. when the new surface may be opened to traffic) depends on the pavement temperature and aggregate size. When pavement temperatures >30°C, and 10 mm or smaller aggregate is used, the new surface may be opened to traffic immediately upon completion of the rolling. The time is usually from 10 to 15 minutes.

The speed of traffic should be restricted to a maximum of 40 km/h until the seal has gained sufficient strength. This is particularly important in cool conditions or when larger, 14 mm, aggregate is used.

The elapsed time at which high speed traffic, i.e. greater than 80 km/h, may be allowed onto the new surface is also a function of the pavement temperature. For a pavement temperature of 25°C, about 1 hour would normally be sufficient. If the pavement temperature is in the order of 8 to 10°C, up to 3 hours is may be required.

Sweeping

Light Brooming of excess loose aggregate should be carried out on the same day. Rollers and vacuum brooms should be available for use for a minimum of five(5) hours after covering the emulsion seal with aggregate. Any remaining particles of loose aggregate should be removed from the pavement on the following day.
FOAMED BITUMEN
SPRAYED SEALING
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<td>(a) Aqueous Phase</td>
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<td>(b) Bitumen Phase</td>
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<td>Aggregates</td>
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<tr>
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<td>FB-6</td>
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INTRODUCTION

This Section of the Guide has been written to explain the use of foamed bitumen sprayed sealing.

Note: This following text in no way constitutes an endorsement by the Authority.

Background

Foamed bitumen technology was developed by Mobil Oil Francais (MOF) in the 1970s as an energy efficient and environmentally acceptable process, and patented in 1978. Since that time the use of foamed bitumen sprayed seals in France has increased to more than two million square metres per annum.

What is Foamed Bitumen?

Foamed bitumen is essentially an inverted bitumen emulsion (i.e. a small amount of water in bitumen) of low stability. It is manufactured and sprayed in situ using a specially designed spraybar / distributor system.

It is a hot process with bitumen at 160-190°C prior to the addition of the water and foaming agent at or after the spraybar.

The bitumen is expanded in volume by aerating, and combining with water (which turns to steam) and a foaming agent. The resultant binder is soft with good aggregate wetting properties for a short period (a few minutes). The binder reaches full strength in less time than most bitumen emulsions and outback bitumen binders.

Aggregate is then applied and allowed to sink into the foam layer. The aggregate particles are half embedded and coated in the layer when the foam breaks. Aggregate interlock is achieved by rolling with pneumatic-tyred rollers.

Benefits of Foamed Bitumen Sealing

The main benefits of the foamed bitumen sprayed sealing include the following:

- an environmentally sound process because it does not require cutter oils which produce hydrocarbon emissions
- a more energy efficient process than conventional hot bitumen sealing because no refined petroleum fuels are used (as cutter oils)
- a potentially more cost efficient treatment compared to bitumen emulsion and outback bitumen
- the rapid development of aggregate interlock under rolling and traffic leads to reduced disruption to traffic during sprayed sealing and after care.

SELECTION AND USE OF FOAMED BITUMEN

General

Foamed bitumen is generally appropriate for sprayed sealing and rescaling applications. It may be used for spraying at pavement temperatures greater than 15°C (generally) without cutter oils or fluxes, and can extend the sealing season.

The foaming action increases the height of the binder and coats the aggregate particles more effectively. This provides better aggregate "wetting" than hot bitumen.

A comparison of foamed bitumen with alternative sealing binders and pavement temperature conditions is summarised in Table FB1.

MATERIALS

Binder

Foamed bitumen binder is a two phase system consisting of the following:

(a) Aqueous Phase

The aqueous phase comprises approximately 2 to 3% by mass of the total mixture. It consists of potable water and includes a small percentage (1 to 5% by mass) of tension active agent.
TABLE FB1
PERMISSIBLE PAVEMENT TEMPERATURES FOR VARIOUS BINDERS

<table>
<thead>
<tr>
<th>Type of Binder</th>
<th>Pavement Temperature (°C)</th>
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<tr>
<td>Hot bitumen</td>
<td>38 - 50</td>
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<tr>
<td>Hot cutback bitumen</td>
<td>10 minimum</td>
</tr>
<tr>
<td>Polymer modified bitumen</td>
<td>25 minimum</td>
</tr>
<tr>
<td>Scrap rubber bitumen</td>
<td>20 minimum</td>
</tr>
<tr>
<td>Foamed bitumen</td>
<td>15 minimum</td>
</tr>
<tr>
<td>Bitumen emulsion</td>
<td>5 - 40</td>
</tr>
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</table>

(b) Bitumen Phase

The bitumen phase of the binder may be Class 50, 170 or 320. It should be
selected on the same basis as conventional sealing to suit local conditions.

It contains less than 1% of a foaming agent
designed to control the expansion of the
bitumen. The expansion is between 5 to
10 times the volume of the base bitumen at
the same temperature (160°C to 170°C).

The system allows for a range of binders to
be used. Foamed bitumen has been
successfully made with a variety of
polymers generally used for road
applications.

High viscosity binders can be used without
the addition of cutter or flux oils. The foam
process provides the viscosity reduction
required in the bitumen to allow wetting
and adhesion of both the aggregate and
the pavement.

Aggregates

High quality aggregate should be used. The aggregate source should be chosen
by the same criteria used for conventional sprayed sealing work.

Special requirements are:
- the aggregate should be clean and dry
- precoat is generally not required unless the aggregate is dirty, and
precoating is the only available
technique by which the dust problem
can be overcome.

NOTE: Most Australian aggregates have a
low affinity for bitumen and are usually
precoated.

When precoating is desirable, a suitable
precoating material is a 4:1 mixture of
water and emulsion. This precoating
should be carried out about two days
before using the aggregate.

Additives

The foaming agent, normally a long chain
fatty acid, controls the expansion of the
bitumen. In addition to the volume, it also
controls the viscosity of the resultant
foamed bitumen.

The surface active agents in the foam act
as anti-stripping agents and also promote
adhesion.
Foamed Bitumen Seal Design

Foamed bitumen may be used for single/single, single/double and double/double sealing applications.

The residual binder and aggregate application rates should be determined in accordance with the local seal design procedures normally used for conventional bitumen seals.

The required application rate for foamed bitumen is determined on the basis of residual binder. No allowance for the water content of the foam is required.

PLANT

General

As the foamed bitumen process, described herein, is a sprayed sealing operation, the equipment is generally the same as for conventional sealing. The only exception being the sprayer which is specifically designed and constructed for spraying foamed bitumen.

Sprayer

The sprayer is equipped with a bitumen tank (capacity 13,000 to 17,000 litres), heating system, air compressor, and tanks for holding water and foaming agents.

The spray bar is collapsible and has a maximum width of 4.2 m. The actual spray width may be varied, and is monitored and controlled through a computer (PC) located in the sprayer cabin.

The entire spraying operation is programmed and controlled by the computer system in the sprayer cabin.

A specially designed and constructed foam spray distribution system is used to manufacture and spray the foamed bitumen. This ensures an acceptable lateral distribution across the spraybar as well as safe handling of the bitumen / water mixtures.

The proportioning of components is critical to the foam properties, application and incorporation of the aggregate.

The nozzles on the spraybar have a circular cross section with separate jets for water and bitumen. The water jet faces upstream and the bitumen jet faces downstream. The bitumen jet is associated with a controlled expansion chamber in which compressed air aerates the bitumen.

The bitumen and water sprays combine just as the mixture hits the pavement creating a foamed bitumen. This foam has a short life span on the pavement surface before collapsing.

An on-board computerised data acquisition and storage system enables a full record of the whole operation to be maintained for Quality Assurance.

Aggregate Spreaders and Rollers

The aggregate spreading and rolling equipment for foamed bitumen work is the same as used for conventional sprayed sealing. Alternatively, self-propelled spreaders may also be used.

The number of spreading trucks should be predetermined to ensure that the binder is covered before it fully collapses.

The width of cockerel spreaders is 2.5 m compared to the maximum spraybar width of 4.2 m.

Rolling is usually completed with ballasted pneumatic-tyred rollers (approximately 12 to 15 tonnes). Normally two rollers are required.

SURFACE PREPARATION

Cleaning

The existing pavement should be swept clean using a rotary road broom, to remove any loose stones, dirt and foreign matter. Sweeping should extend at least 300 mm beyond the edge of the area to be sprayed. Any foreign matter adhering to the pavement and not swept off by the broom should be removed by other means.
Foamed Bitumen Sprayer

Photograph FB1

Spraying Operation

Photograph FB2

Freshly Sprayed Foamed Bitumen

Photograph FB3
Any areas affected by minor oil contamination should be cleaned by an approved method. Where the surface is significantly affected by oil, rectification of the defects will need to be undertaken as described below.

Rectification of Surface Defects

As poor pavement and surface repairs will adversely affect the performance of the surfacing, the following actions should be taken as appropriate:

- if after cleaning the surface is soft, the affected area should be removed and reinstated
- coldmix patches should be removed and the pavement reinstated.

Protection of Services

Precautions should be taken to prevent binder being sprayed onto kerb and gutters, service covers, etc., by using plastic sheeting, paper or cardboard as a mask.

FIELD OPERATIONS

General

As the foamed bitumen process is a sprayed sealing activity, it has all the associated advantages, especially in terms of speed of operation and minimal disruption to traffic.

It is a very precise process, in which adequate planning and proper timing of the various activities are essential.

Foamed bitumen sealing can achieve outputs of approximately 20,000 m²/day.

Weather Limitations

The pavement surface temperature at the time of spraying should be above 15°C with air temperatures uniform and close to the surface temperature.

The pavement surface must be dry at the time of spraying.

Spraying

This activity includes the manufacture of the foamed bitumen and spraying to achieve uniform lateral distribution of the binder (see Photographs FB1 and FB2).

Prior to foaming (spraying), the bitumen should be in the range 160°C to 190°C and the water based additive at ambient temperature.

The process consists of the in situ manufacture of a surface active bitumen by the injection of water and additives. The water content and chemical content are controlled to give a predetermined level of expansion and foam stability.

The reduced need for cutter oil means that the seal gains strength rapidly. The reduced residual solvents also reduces the potential for bleeding in hot weather.

The pavement temperature should be carefully monitored because the foam will collapse more quickly at higher temperatures (see Photograph FB3).

All spraying operations should be carried out with paper masking the start and finish of each sprayer run.

Aggregate Spreading

Control of the aggregate spreading is crucial to the success of the process. The aggregate is spread just as the foam begins to collapse. This critical timing allows the remaining foams to collapse around the cover aggregate ensuring good adhesion.

Before spraying commences, the aggregate spreaders should be in position behind the sprayer so that spreading can commence immediately after spraying has started.

The aggregate spreading trucks should maintain a distance of 5 to 20 m behind the sprayer throughout the run. This distance may have to be varied according to the size of the aggregate and weather conditions. Care must be taken to achieve the required aggregate spread rates while the trucks are operating close to the sprayer.
The distance should be sufficient to enable the foam to collapse to about two thirds of its initial volume when the aggregate is applied. It also must be small enough to ensure that the binder has not completely stiffened, allowing incorporation of the aggregate.

Cross winds will collapse the foam at a greater rate than normal and therefore, if cross winds prevail, the spreader should be positioned closer to the sprayer.

Coating of the aggregate particles by the collapse of the foam increases the surface area of aggregate coated with binder and the finely divided nature of the foam, together with the chemical additives, maximises interfacial wetting and therefore adhesion.

The length of sprayer run and the spraying width will be determined by the ability to spread the cover aggregate as the foam is collapsing. There should be sufficient aggregate spreading trucks so that the aggregate can be spread before the foam has fully collapsed and may involve spreading trucks travelling in echelon.

Hand spreading (spotting) should be carried out before the foam has fully collapsed, to avoid plucking or stripping.

Rolling

The process is completed by rolling with pneumatic-tyred rollers in the usual manner.

Rolling should not proceed until the foam has completely collapsed around the aggregate particles but must be carried out before the binder has completely stiffened. In effect, this means that rolling should proceed within 5 minutes of the spraying. The rolling pattern should be the same as for conventional hot bitumen sealing work.

The improved wetting characteristics of foamed bitumen enables rapid development of aggregate interlock under rolling, and also reduces the potential for damage under traffic.

Traffic Time

The new surface may be opened to traffic immediately upon completion of the rolling, which is usually about 30 minutes.

Controlled traffic speeds should be continued for about 3 to 4 hours.

Sweeping

The seal should be swept the same day. Care should be taken not to dislodge aggregate particles by arranging a pneumatic tyred roller to follow the sweeper.