SELECTION OF SURFACINGS

1 INTRODUCTION

These notes are based on text from the Austroads *Guide to selection of road surfacings*. Additional detail may be obtained by reference to a copy of the Guide and other referenced material including the Austroads *Asphalt Guide*, Austroads *Selection and Design of Asphalt Mixes: Australian provisional guide*, Austroads *Sprayed Sealing Guide* and various APRG/AAPA Pavement Work Tips.

These notes are divided into three parts: selection of surfacing for new pavements, selection of surfacing for retreatments and description of principal surfacing types.

2 SELECTION OF SURFACING FOR NEW PAVEMENTS

2.1 General

The selection of a surfacing type for a new pavement includes a combination of structural requirements, and necessary surface characteristics.

The major structural factors are:

- traffic volumes, and masses of commercial vehicles
- subgrade conditions and availability of pavement materials
- accepted local practice
- whole-of-life cost, including maintenance practices and requirements.

The major surface characteristics are:

- texture (skid resistance, noise)
- shape (ride quality)
- resistance to traffic stresses.

Location and traffic volumes are major influencing factors. Lower cost sprayed seals and thin asphalt surfacings are commonly used in rural locations and for lower traffic volumes, whereas the more expensive bound pavements (asphalt or concrete) are used in urban areas and for more heavily trafficked pavements.

A number of optional approaches to selection of surfacing are available to users of this guide depending on the experience and information available to the user.

Generally, the first step is to select a pavement with a generic surfacing type. Preferably, the user should go through a detailed process that takes into account all the factors outlined above. An indicator of likely pavement and generic surfacing type is shown in Tables 1 and 2. A more detailed analysis is provided in the Austroads AP-G63/03 : Guide to the Selection of Road Surfacings (2nd ed.).

Following this, the user must determine the particular surfacing to be used. The following sub-sections provide a guide to the most commonly selected surfacings for the different types of pavement commonly used in Australia. Final selection may require further reference to the detailed comments about particular surfacings discussed in earlier sections.

2.2 Selecting generic surfacing type

Tables 1 and 2 provide an indication of the most likely generic type of surfacing that will provide the level of service required at minimum life cycle cost, based on major factors of location and traffic. This should be used as a general guide only and does not substitute for proper whole-of-life costing analysis.

For a discussion on life cycle costing, refer to AAPA Implementation Guide IG-7: Comparison of Pavement Alternatives.

Table 1 Selection of surfacing for new flexible pavements on rural roads

Traffic loading	Light/medium/high		Very high (including town streets)
Surface stress level	High	Low	All
Likely generic surfacing type	Asphalt Double/double seal	Single/single seal	Asphalt Double/double seal

Table 2 Selection of surfacing for new flexible pavements on rural roads

Traffic loading	Light		Medium/High	Very high
Surface stress level	High	Low	All	All
Likely generic surfacing type	Asphalt Double/double seal	Single/single seal	Thin asphalt/ granular Thick asphalt	Thick asphalt

2.3 Guide to commonly selected pavement and surfacing combinations

The common surfacings applied to each of the major types of pavement constructed in Australia are described in the following sub-sections.

2.3.1 Granular pavements with sprayed seal surfacings

Granular pavements with sprayed seal surfacings comprise the predominant surfaced pavement type in rural areas.

For minor and low traffic roads, initial treatments usually use 10 mm and 7 mm aggregates.

For major roads, 10 mm and 14 mm are the most common sizes except for heavy duty pavements such as National Highways, where a two-application seal may be used.

A prime and seal is considered to be a better surfacing treatment than a primerseal, however a prime and seal can only be carried out on a dry pavement which is generally free from traffic (e.g. a new freeway) or under minimal traffic.

On the other hand, a primerseal can be placed on a damp pavement, and allow immediate trafficking.

A geotextile reinforced sprayed seal is a particular form of initial treatment sprayed seal used when available pavement materials are extremely poor (see Section 3).

Details of all spray seal types are provided in Section 4.

2.3.2 Granular pavements with thin asphalt surfaces

Asphalt surfaced granular pavements tend to be used in urban areas for both minor arterial and local roads, as well as some major rural arterial roads. They may also be used for localised treatment of intersections and areas of heavy turning movements on roads surfaced with a sprayed seal.

It is important that these types of pavements have a sprayed seal or a primed surface beneath the asphalt surface to provide a waterproofing membrane.

The most common surfacing types are dense graded asphalt of 7 mm or 10 mm size for lighter trafficked pavements or lower speed environments, and 10 mm or 14 mm size for heavier traffic applications. Detailed asphalt mix selection criteria are provided in Section 4.

2.3.3 Thick asphalt pavements

Thick asphalt pavements have an asphalt base together with a sub-base comprising asphalt, cement treated crushed rock or unbound granular materials, and are commonly used for major urban or rural arterial roads or freeways.

The most common surfacing type is 14 mm dense graded asphalt, except where open graded asphalt is required for operational requirements. Open graded asphalt should be placed on a well compacted size 14 mm asphalt and a heavy tack coat or sprayed seal (depends on local practice) used on top of the 14 mm asphalt, before the open graded asphalt is placed, to ensure waterproofing.

Binder type and mix design requirements will vary with traffic loadings (refer Section 5).

2.3.4 Cementitious bound bases with sprayed seals

Cement bound bases with sprayed seal surfacing are more commonly associated with rehabilitation treatment of granular pavements than with new construction.

Surfacing performance requirements are generally the same as for unbound granular pavements, other than the need to consider the possibility of shrinkage cracking. Polymer modified binders are appropriate in such circumstances.

2.3.5 Cementitious bound bases with asphalt surfacing

As for the bound, spray seal surfaced, pavements above, this type of construction is often associated with rehabilitation of existing pavements as well as new construction. Similar consideration must be given to the possibility of reflection cracking and the use of polymer modified surfacing – refer to Strain Alleviating Membrane Interlayer (SAMI) treatments in Section 4.

3 SELECTION OF SURFACING FOR RETREATMENTS

3.1 General

In selecting a surfacing retreatment the practitioner/asset manager is offered a wide array of choice. As well as the relatively straightforward options applicable to new surfaces, there are further options depending on whether the need is merely to restore surface condition, improve shape or ride quality, or compensate for more serious pavement deficiencies. The challenge is to select the most suitable treatment that satisfies technical performance criteria in the most cost-effective manner.

3.2 The Selection Process

The basic steps are outlined below. The level of detail used in the selection process will, however, vary substantially depending on the complexity and importance of the job, and the experience used in the selection process.

1. ASSESS EXISTING CONDITIONS

   Assessment comprises three parts:

   - Road database records and/or visual inspection
   - Testing, if required. (e.g. skid resistance, deflection)
   - Required performance characteristics of new surfacing.

2. DETERMINE FEASIBLE OPTIONS

   Generally, the most economic satisfactory solution should be considered first, taking into account limitations imposed by deflections, curvature, roughness and/or permeability, and life-cycle costs.

   For example, a thin layer of asphalt (say 25 to 30 mm) used as a surfacing on a weak granular base may be more expensive, and have a shorter life, than a single or double application sprayed seal, due to the limited ability of the asphalt to tolerate pavement deflections and curvature, and adequately waterproof the base.

   Reference may be made to Tables 3 and 4 as a guide to matching treatment type against influence of the treatment on a particular characteristic.

3. ANALYSE OPTIONS

   Broad assessment using the techniques referred to above, together with a simple economic analysis, may be sufficient information/guidance for many retreatment situations. Further detailed analysis may need to be applied to meet specific performance objectives as well as cost effectiveness.

3.3 Effect of resurfacing/resurfacing treatments on existing surface characteristics

The following tables give generic descriptions of the effectiveness of different surfacing treatments on correcting deficiencies in existing pavements. The properties mentioned are for newly placed surfacings after a settling-in period. For example:

- skid resistance of new surfacings will be low for a short time until the bitumen or precoating material has worn or been washed off,
- new seals maybe tender until they are bedded down, some of the cutters removed, or, for emulsions, the emulsion has fully broken,
- asphalt surfaces may be tender until cooled sufficiently or tightened by the action of traffic.

Table 3 Effect of resurfacing/resurfacing treatments on existing surface characteristics: Asphalt

Property requiring improvement	**Influence of asphalt treatment**				
	Dense graded asphalt (DGA)	**Fine gap graded asphalt (FGGA)**	**Stone mastic asphalt (SMA)**	**Open graded asphalt (OGA)**	**Ultra-thin open graded asphalt (UTOGA)**
Bitumen ageing/ oxidation	Covers oxidised surface	Covers oxidised surface	Covers oxidised surface	Covers oxidised surface. Requires seal or heavy tack coat on existing surface to minimise moisture infiltration into the pavement.	
Roughness	All asphalt treatments result in a smooth machine laid surface. Improvement to the shape of existing surfaces may require additional use of regulation layers (usually with dense graded asphalt).				
Waterproofing properties	Good if adequate compaction and layer thickness	Good if adequate compaction and layer thickness	Good if adequate compaction and layer thickness	Surfacing is permeable but can be combined with heavy tack coat or seal for waterproofing	
Skid resistance	Good at low speeds, reducing as speed increases	Suitable for low speeds only	Good	Good	Good
Structural strength	Improves strength depending on layer thickness	Some minor improvement but normally a surfacing only	Improves strength depending on layer thickness	Minimal	None
Robustness / shear resistance (relating to braking and turning traffic)	Excellent	Excellent	Good	Generally poor	Generally poor
Water spray	Poor	Very poor	Some reduction	Excellent	Excellent
Permeability of surface	Low	Low	Low	Surfacings are designed to be permeable	
Flexibility	Relatively stiff but also influenced by binder type	Greater flexibility than dense mixes	Relatively flexible	Low stiffness	Low stiffness
Shape correction ability	All asphalt treatments result in a smooth machine laid surface. Improvement to the shape of existing surfaces may require additional use of regulation layers (usually with dense graded asphalt).				
Likely life of treatment	8 to 25 years	15 to 25 years	10 to 25 years	7 to 15 years	7 to 10 years

Table 4 Effect of resurfacing/resurfacing treatments on existing surface characteristics: Sprayed seals

Property requiring improve-ment	**Sprayed seal treatments**				**Slurry/ microsurfacing**		**Combined Treatments**	
	Surface enrichment	**Single/ single**	**Double/ double**	**Geotextile reinforced**	**Slurry Seal**	**Micro-surfacing**	**Regulate plus geotextile reinforced sprayed seal**	**Regulate plus geotextile reinforced sprayed seal with asphalt overlay**
Bitumen ageing/ oxidation	Delays further oxidation							
Roughness	No effect				Some improvement, more with multiple layers		Good	Very good
Water-proofing properties	Reasonable	Good	Very good	Excellent	Minor improvement		Excellent	
Skid resistance	May reduce	Excellent			Fine texture good at low speeds but may reduce at high speeds		Excellent	As for asphalt
Structural strength	No effect					Minimal to no effect	Depends on thickness of asphalt layers	
Robustness (relating to sharp turning traffic)	No effect	Poor, but improved with modified binders	Some improvement over single seals due to interlocking aggregate		Moderate to good		More robust if double application used	As for asphalt
Water spray	No effect	May achieve some improvement depending on aggregate size			Minimal effect		Good	As for asphalt
Permeability of surface	Some reduction	Low			Moderate to high		Low	
Flexibility	No effect	Remains same as existing surface			Poor		Good	Good
Shape correction ability	No effect				Some improvement. More with multiple layers		Good	Very Good
Surface reflection cracking	Little effect	Good	Very good	Excellent	Poor		Excellent	Excellent
Likely life of treatment[1]	2 to 5 years	5 to 15 years	8 to 15 years	8 to 15 years	5 to 10 years		5 to 10 years	5 to 12 years

Notes: 1. Surfacing life depends on the condition of the existing surface and structural condition of the pavement.

3.3 Guide to Retreatment Types

A brief description of each of the surfacing types referred to in the tables follows. For more detail refer to referenced documents.

3.3.1 Sprayed seals

While not strictly a hierarchy, sprayed seals and other thin surfacing options (including slurry surfacing and asphalt) tend to a form of progression in terms of cost, which can then be related to the particular performance levels required. Sprayed seal types are listed below.

Reseals: A reseal using normal (unmodified) binder is the standard retreatment for the majority of sprayed seal surfaced roads.

Sprayed seals may also be used on asphalt pavements to waterproof the surface, improve surface texture and prevent further oxidisation of aged surfaces.

The size of seal should be related to the surface characteristics required as well as the texture of the surface being treated.

Two application reseals are used where a particularly heavy-duty treatment is required but with the surface texture of the smaller aggregate used.

Reseal with a slightly modified binder: A reseal with slightly modified binder may be used as a high stress seal (HSS) to improve aggregate retention on heavily trafficked high speed roads. It may also be used on slightly distressed pavements as a light duty strain-alleviating membrane (SAM).

Reseal with heavily modified binder: A reseal with a heavily modified binder may be used to provide a higher level of aggregate retention on heavily trafficked high speed roads, or as a SAM or SAMI treatment.

Fibre reinforced seals: A fibre reinforced seal is considered to have properties somewhat better than those of a heavily modified sprayed seal, but not as good as those of a geotextile reinforced seal (see below). Considerably more monitoring of this type of seal will be required before a more definitive ranking can be given.

Geotextile reinforced seals: Geotextile reinforced seals are used to provide a heavy duty SAM or SAMI treatment on selected areas of heavily distressed, heavily loaded pavements. Single application geotextile seals should only be used when not subject to turning traffic. A double application seal using a modified binder in the first layer of binder provides a higher level of performance than a single application with a modified binder or a double application with standard binder.

3.3.2 Slurry

Slurry surfacing is a thin bituminous surfacing treatment providing a uniform surface and minor shape correction – refer Section 5.

3.3.3 Asphalt

Dense graded asphalt (DGA): Dense graded asphalt (or asphaltic concrete) is the most commonly used type of asphalt surfacing. A wide range of mix types can be used depending on traffic requirements, shape correction and surface texture required. Thicker layers can be used to increase the structural strength of pavements.

Stone Mastic Asphalt (SMA): SMA may be used as a resurfacing where a well-textured, deformation resistant mix is required, although at a higher cost. SMA mixes also provide high fatigue and crack resistance. SMA mixes may not be readily available in some locations.

Open Graded Asphalt (OGA): OGA is used as resurfacing where the noise and water spray reductions of a porous surfacing are required. It is important that OGA be placed on a sound, waterproof surface.

Thin open graded asphalt: Thin open graded asphalt surfacing is placed in combination with a heavy tack coat layer to waterproof and bond the surfacing layer to the underlying surface.

Fine gap graded asphalt (FGGA): FGGA is used to provide a fine textured surface using a durable asphalt mix suitable for residential streets and other light duty applications.

3.3.4 Combination Treatments

A number of the above treatments can be combined, including innovative rehabilitation treatments that provide a combination of surface texture, flexibility and shape correction that cannot practically be achieved with the individual surfacing treatments alone.

Examples of combination treatment are:

- Use of a SAMI treatment under dense graded or open graded asphalt to waterproof the surface and resist reflection cracking
- Regulation and shape correction of a rough surface with a thin asphalt layer or slurry surfacing followed by a sprayed seal (standard or polymer modified binder depending on the degree of crack resistance and waterproofing required)
- Treating a rough, weak, badly cracked surface by regulating with a thin, flexible layer of asphalt to correct the shape, applying a geotextile reinforced sprayed seal membrane to waterproof the pavement and reduce the effect of reflective cracking. This treatment may be used:
  - alone as a single application sprayed seal in appropriate conditions,
  - as a double application sprayed seal,
  - followed by an open graded asphalt or ultra thin asphalt to provide a smooth, quiet surface, or,
  - followed by dense graded or stone mastic asphalt.

4 SPRAYED SEALS

4.1 Binder

The class of binder most commonly used for spray sealing in Australia is Class 170 bitumen, although some use is made of Class 320 in hotter regions.

Multigrade binders and polymer modified binders are also available and may be considered for special applications.

Bitumen is normally a semi-solid that softens on heating. For most sprayed seal (and hot mix asphalt) applications, bitumen is liquefied by heating.

Cutter oils are also used to reduce viscosity of sprayed seal binders only. Small amounts may be used in spray seal work to improve spraying and adhesion in cool conditions. More cutter is used in primersealing work to achieve bonding to the untreated base, while greater quantities are used in primers to achieve penetration of the base.

An alternative to heating or use of cutters is emulsification, where fine droplets of bitumen are suspended in water. Typical emulsions used in spray sealing and slurry surfacing contain 60 to 80% bitumen.

A further alternative to use of cutters or emulsification is the addition of a small amount of water to hot bitumen to create an expanded volume through controlled foaming. This is done in a purpose-built sprayer, and can provide suitable fluidity for use in spray seals and surface enrichment. This process provides particularly rapid curing due to the absence of cutters or emulsification.

All of the above binder types can also be modified by the addition of polymers for particular applications.

4.2 Prime

A prime is a temporary surfacing which is followed some time later by a sprayed seal or asphalt surface. A prime is a sprayed layer of primer (bitumen and cutting oil mixture or a formulated bitumen emulsion primer) without cover aggregate. It is used to bind the surface of an unbound granular layer, provide a bond onto which a bituminous surfacing can adhere, and provide a surface that retards the absorption of the bitumen, from the bituminous surfacing, into the pavement. It can also assist in waterproofing and protecting the pavement.

A prime or primerseal is always recommended over granular pavements.

If the pavement is not primed correctly the binder in the seal could:

- be affected by the fine dust materials at the surface of the pavement and "ball" (inadequately wet the surface), hence inadequately adhere to the underlying primed surface,
- be absorbed into the pavement surface, hence leaving insufficient binder to hold the aggregate in position,
- flush, bleed or pick up. This is often the result of too much prime, or a wet pavement not allowing the prime to soak into the pavement, hence resulting in too much binder around the aggregate.

4.3 Primerseal

A primerseal is an initial treatment where a primerbinder is sprayed onto a prepared pavement surface (i.e. not primed) and is covered with a layer of aggregate. It allows immediate trafficking, and permits a delay in placing the final surfacing for logistical or operational reasons.

A cutback primerbinder is manufactured with about 12 to 20 parts of cutter to 100 parts of bitumen (plus adhesion agents) to assist the primerbinder to "wet" and penetrate the surface of the pavement. If the bitumen in the primerbinder is not cutback sufficiently it could "ball" (i.e. it may not be uniformly spread across the pavement and/or it may not bond to the underlying surface).

A bitumen emulsion primerbinder may also be used. The emulsion primerbinder must uniformly "wet" the surface of the pavement if it is to bond to the underlying pavement.

Emulsion primerbinders can be specially formulated for this purpose, and must perform the same function as cutback bitumen primerbinders.

For both cutback and emulsion types of binder, the pavement should normally be damp (not wet) to assist in the "wetting" process.

Failure to primerseal properly can result in similar problems to those described previously for incorrectly primed pavements.

4.4 Seals and reseals

A seal is formed by the spraying of binder and covering with a layer of aggregate.

A seal may contain more than one application of binder and/or aggregate.

The term "reseal" is often used interchangeably with the generic term "seal". A "seal" or "initial seal" is a term commonly used to describe the first sprayed bituminous surfacing applied over a primed, or primersealed surface. A "reseal" is the term used to describe the application of a sprayed bituminous surface over an existing bituminous surface as part of a periodic maintenance program.

A pavement is resealed as part of a periodic maintenance program when the condition of the existing surface requires the application of new binder and aggregate to restore one or more of the functions of the original seal. This provides a new wearing surface on which vehicles run, and re-waterproofs the pavement.

4.5 Size of aggregate used in sprayed seals

4.5.1 Size range

The use of aggregate sizes ranging from sand up to 14mm is common in single seals. Size 16 and 20mm aggregates are occasionally used in single seals as wearing surfaces, but more commonly restricted to use as the larger aggregate in multiple application seals.

4.5.2 Sand seals

These may be used:

- to reseal pavements on very low traffic roads
- to create a smooth final surface on tennis courts and footpaths
- as part of an untrafficked temporary treatment to waterproof the pavement after construction, e.g. a road which will not be opened to traffic for some time.

4.5.3 Size 5 and 7 mm seals

These may be used:

- as a surfacing treatment for lightly trafficked pavements,
- as a second application on top of a size 10, 14, 16 or 20mm seal. In this case the seal will sometimes be two stone thickness, the first being located in the interstices of the original aggregate, and the second layer providing the running surface by covering the original aggregate.
- as part of a "rack-in", "pin down" or "blinding" treatment to a large sized seal, where the points of the aggregate from the original seal form the running surface. Aggregate rack-in and blinding treatments are usually applied without further binder.
- as part of an untrafficked temporary treatment to waterproof the pavement after construction, e.g. a freeway that will not be opened to traffic for some time.

4.5.4 Size 10 and 14 mm seals

These are usually used as a sprayed seal surfacing where there is sufficient traffic volume to warrant the use of a large sized aggregate, e.g. traffic volumes greater than 300 vehicles/lane/day.

4.5.5 Size 16 and 20 mm seals

These are usually used in combination with a smaller sized aggregate in a two application/multiple application seal to provide a robust heavy duty seal, e.g. haul roads, snow country subject to snow clearing operations, ford crossings of creeks and other applications. Size 16 and 20mm single coat sprayed seals are sometimes used, however the quantity of bitumen needed to retain the aggregate tends to make them less economic than smaller sized seals, and loose size 16mm and 20mm aggregate on the road surface can create safety problems.

4.6 Multiple application seals

4.6.1 Multiple application of binder and aggregate

A double application seal is constructed by spraying a layer of binder, spreading the large sized aggregate and, after trafficking and/or suitable rolling, spraying another low application of binder followed by the spreading of a layer of smaller aggregate so that the smaller aggregate fits into the interstices between the bigger aggregate and locks it into place.

Double application seals are used when additional waterproofing must be ensured, and where a fine texture is required (parking areas, residential streets, footpaths etc.). In areas of high loading and stress, multiple application seals give improved aggregate retention when compared to single application seals if they are correctly designed. Incorrectly designed multiple application seals can become fatty (most common) or strip.

In remote areas the second application of a double application seal has been used to protect the binder in the bottom layer from extreme climatic conditions and dust, hence increasing seal life.

Normal combinations of aggregate are:

a) 10 mm with a 5 mm aggregate,
b) 14 or 16 mm with a 5 or 7 mm, or occasionally a 10 mm aggregate,
c) 20 mm with a 7 or 10 mm pinning aggregate.

4.6.2 Single application of binder and double application of aggregate

A variation of a double application seal, referred to as a double single seal or a seal with a racked in aggregate, is constructed by spraying a layer of bitumen, spreading the large sized aggregate at less than the normal spread rate and, after suitable rolling, spreading another layer of smaller aggregate so that the smaller aggregate fits into the interstices between the bigger aggregate and is locked into place by a small amount of bitumen (from the first spray).

This type of seal is used in some heavy traffic applications to prevent traffic rolling and dislodging coarse aggregate particles while the binder is still fluid. It is particularly applied when using emulsions as described in the following sub-section.

4.7 Sealing and primersealing with bitumen emulsions

Seals and primerseals can be constructed using bitumen emulsion binders and all sizes of aggregate.

Single application seals using large aggregates must be combined with high bitumen content emulsions (68% or greater) to avoid drainage of the binder from the surface while still fluid. Such seals also commonly use a smaller size aggregate as a "rack in" treatment to assist in anchoring the larger aggregate particles while curing of the binder takes place.

Primerseals using bitumen emulsion may use sand, or sizes 5, 7 or 10 mm aggregates.

The size used is dependent upon the traffic volume being carried. Normally size 5 or 7 mm aggregate would be sufficient for lightly trafficked roads, with size 10 mm aggregate being used on more heavily trafficked roads.

4.8 Surface enrichment/rejuvenation

The surface enrichment of a sprayed seal surface results from the spraying of a light application of a light grade of bituminous material (cutback or emulsion) or foamed bitumen onto the surface so that it can run into the voids in the existing aggregate. This treatment increases the amount of binder in the layer, but care must be taken to ensure that adequate surface texture remains. This extends the life of the surfacing by ensuring the retention of the existing cover aggregate, and can waterproof the surface.

Enrichment treatments are normally only used where traffic volumes are low and traffic can be diverted onto another lane or road, or on road shoulders.

Surface enrichment can also be applied using proprietary rejuvenating agents.

A further form of surface enrichment is the use of rejuvenating agents on asphalt.

4.9 Polymer Modified Binders

Polymer Modified Binders (PMBs) are used in spray seal work:

- as a High Stress Seal (HSS) to improve aggregate retention,
- as a Strain Alleviating Membrane (SAM) to absorb strains that can cause reflection cracking in the applied sprayed seal, or,
- as a Strain Alleviating Membrane Interlayer (SAMI) to absorb reflection cracking in applied asphalt overlays.

A detailed guide to PMB grades and applications is provided in the Austroads Framework Specification for Polymer Modified Binders

4.9.1 Slightly modified binder for use in HSS and light duty SAM sprayed seals

Sprayed seals with slightly modified binder include:

a) 5 parts (4.8%) crumbed rubber
b) a small percentage of polymer in the binder (Grade S10E).

These types of seals normally use aggregates of size 10 or larger.

Slightly modified binder sprayed seals are used:

- to act as a strain alleviating membrane (SAM) where crack widths are <2 mm and traffic is <100

cv/lane/day,

- to act as a strain alleviating membrane (SAM) over cracked surface clearly caused by environmental factors,
- to improve aggregate retention on high speed facilities, moderately stressed areas typified by grades <5%, curves >50 m radius, intersections, T-junctions and heavy traffic entrances involving moderate degrees of braking, acceleration and turning movements
- to increase binder viscosity in areas with high pavement temperature.

4.9.2 Medium and heavily modified binder for use in HSS and heavy duty SAM

Medium and heavily modified binder sprayed seals include:

a) 20 to 25 parts (17 to 20%) crumbed rubber added to the binder,
b) polymer added to the binder (medium modified grades S20E, S35E or heavily modified grade S25E).

Heavily modified binder seals are generally combined with 14 mm aggregates rather than smaller sizes, in order to obtain the desired thickness of binder for SAM applications.

The heavily modified binders are used:

- to act as a strain alleviating membrane (SAM) for load associate cracking, where some of the cracking is > 2 mm and traffic is > 100 cv/lane/day,
- to act as a seal on a geotextile placed over load induced, diurnal and seasonal cracking,
- to act as a holding seal prior to treatment by a geotextile seal or reconstruction of a pavement in very poor condition,
- as a seal over cement treated crushed rock.
- at a site of severely stressed areas typified by grades > 5%, curves < 50m radius, intersections, T-junctions and heavy traffic entrances involving severe degrees of braking, acceleration and turning movements. It may also be necessary to pin-down or rack in the sprayed seal in these circumstances.

4.9.3 Heavily modified binder for use in SAMI and other heavy-duty spray seal applications

Heavily modified binder sprayed seals for SAMI applications include:

a) 25 parts (20%) crumbed rubber added to the binder,
b) polymer added to the binder (Grade S25E).

SAMIs should only use aggregates of size 10 or larger.

SAMIs are used to:

- act as a strain alleviating membrane interlayer between a cracked pavement and a new asphalt overlay,
- beneath an open graded asphalt to ensure that the base is waterproof.

4.10 Fibreglass reinforced emulsion sprayed seal

This technology is currently marketed under the trade name Fibredec.

A fibre-reinforced seal usually uses a polymer modified emulsion. The process uses a purpose-built sprayer which, with a single pass:

- sprays the first layer of binder onto the pavement
- cuts the required amount of fibre glass to length, and blows this onto the first layer of binder. Fibres are cut to length, and can be 50 mm and up to 90 mm in length
- sprays a second layer of binder over the cut fibres.

The bitumen and fibre layers are immediately covered with a "lightly spread" aggregate (say a 14 mm) which is locked into place using a "racked in" size 5 or 7 mm aggregate.

There is insufficient data available at the time of publishing to determine the efficiency of this type of seal, but it is believed that its properties are somewhere between highly modified binder seals and geotextile reinforced seals. The length of the fibres is also believed to influence the effectiveness of this type of sprayed seal.

4.11 Geotextile reinforced seals

Geotextile reinforced sprayed seals are currently considered to be the most cost effective sprayed sealing technique for treating badly cracked and distressed pavements (bound and unbound pavements), particularly where the crack movements are large and slow, as caused by environmental factors.

The two common types of geotextile reinforced seal are:

a) single coat (often using a modified binder)
b) double coat (using modified or unmodified binder in the first spray of binder and slightly or unmodified binder in the second layer).

Geotextile reinforced sprayed seals are produced by spraying a layer of bitumen onto a pavement (bond, or tack, coat) then covering this bitumen with a layer of geotextile and lightly rolling.

A single or double application seal is then applied over the geotextile.

Geotextile reinforced sprayed sealing treatments, in common with all sprayed sealing techniques, do not improve the shape or ride of the pavement. They can, however, be applied on top of a regulation treatment (of slurry or asphalt). It must be recognised that the potential life of the geotextile treatment may be influenced by premature distress in the regulation layer or the poor condition of the original pavement.

Geotextile seals can also be used as a membrane under asphalt (DGA, OGA and UTOGA), particularly in combination treatments.

A further use (application) of geotextile reinforced seals is as an initial treatment on pavements constructed with clay and other poor quality pavement materials. This treatment has been successfully used in remote areas of NSW where reasonable quality granular pavement materials are unavailable and pavements must be constructed using local clay soils. These materials can provide adequate bearing capacity, provided that surface cracking is avoided in dry periods and moisture entry prevented in wet periods. For further details refer to RTA NSW "Guide to the Design, Construction, Maintenance and Management of Clay Pavements with Geotextile Reinforced Seals".

4.12 Specialty binder seals

Specialty binders include epoxy and polyurethane modified materials, as well as other forms of polyester and resin esters. These have been particularly developed as specialist treatments, in association with polish-resistant aggregates, to provide exceptional skid resistance in high risk areas such as sharp curves and approaches to pedestrian crossings or traffic lights.

They may also be used in surfacing of steel surfaces such as bridge and ferry decks.

Specialty binder seals can be used in combination with calcined bauxite, slag or natural aggregates of suitable hardness and resistance to traffic polishing. Usual sizes are 3 mm to 5 mm, although larger sizes can be used.

Specialty binder systems are generally marketed as complete systems. High cost tends to restrict use to special cases and specialist advice is advisable.

5 ASPHALT SURFACINGS

5.1 General

This section describes the binders and types of asphalt mixes used as surfacings and other applications.

5.2 Binder

Classes of binder used include:

- Bitumen class 170, 320, 600 and multigrade,
- Polymer modified binders (including crumbed rubber).

Asphalt using polymer modified binders and multigrade has improved properties compared to asphalt made from conventional binders. The choice of binder will affect the stiffness, fatigue life and rut resistant properties of the asphalt.

The Austroads Specification Framework for Polymer Modified Binders assists in the selection of the most appropriate modified binder for a given situation.

5.3 Dense graded asphalt (DGA)

The most common type of asphalt is a dense graded mixture of continuously graded aggregates, sands, filler and bitumen which is mixed and placed hot. This type of mixture is also known as asphaltic concrete (AC).

The strength of dense graded asphalt is mainly derived from friction between the aggregate particles and the viscosity of the binder at the operating temperature. Common modes of distress for asphalt layers are:

- permanent deformation under heavy traffic due to insufficient stability,
- cracking due to fatigue, and
- ravelling due to oxidation and hardening of the binder.

By varying the aggregate combination to provide a range of different air voids, and using different grades of binder, asphalt properties can be altered to suit applications from low traffic areas to freeways and heavy duty areas such as airports and container storage areas.

In lightly trafficked areas, the asphalt may fail by ravelling due to oxidation of the binder. To minimise this, a softer grade of binder may be used, and air voids reduced by increasing binder content and or the use of a fine aggregate grading. Fine gap graded mixes are a modified form of dense graded mix specifically developed to achieve durable asphalt mixes for use in lightly trafficked areas.

On more heavily trafficked pavements it is important that the asphalt does not flush, deform, or fatigue under the action of traffic. Resistance to flushing and deformation is improved with coarser gradings and stiffer binders. Polymer modified binders can be used to enhance both rutting resistance and fatigue properties.

A detailed guide to the selection and design of asphalt mixes is provided in Selection and Design of Asphalt Mixes: Australian Provisional Guide (APRG Report No. 18). Further detailed advice on the application of polymer modified binders for asphalt is contained in Austroads Specification Framework for Polymer Modified Binders.

Generally, dense graded asphalt is manufactured in sizes 7, 10, 14, 20, 28 and 40 mm.

A guide to the selection of nominal size is provided in Table 5.

A guide to selection of the design properties of dense grade asphalt wearing course is provided in Table 6.

5.4 Open graded asphalt (OGA)

Open graded asphalt is manufactured with a large proportion of coarse aggregate and only a small amount of fine aggregate. For wearing course applications the size of the aggregate is usually 10 or 14 mm, although 7 mm mixes have been used.

This type of asphalt contains 18 to 25% air voids and is porous by design. This provides:

- lower tyre noise,
- reduced water spray for improved visibility and road safety,
- improved skid resistance through reduced surface water.

Limitations and special considerations in the use of open graded asphalt wearing course asphalt include:

- water entering underlying layers may be increased. In some cases it is desirable to place a waterproofing seal or a uniform, heavy, tack coat prior to the open graded wearing course.
- It is very important to provide an outlet for the water that enters an open graded asphalt, otherwise the layer deteriorates and dust and debris builds up. For this reason, open graded asphalt must have a free-draining edge and must be placed above the lip level of the adjacent kerb and channel (if any). The raised edge may be a hazard to cyclists, hence it may be necessary to minimise its height and consider where the edge is located.
- open graded mixes perform poorly in areas of high surface shearing forces and are generally not suitable for situations such as heavily trafficked intersections
- some benefits can reduce with time due to wear, densification, and clogging of voids
- shorter life expectancy
- little contribution to pavement strength
- reduced water spray
- rapid removal of water from the surface to improve safety.

Open graded asphalt can be manufactured using standard bitumen or modified binders. The usual method of failure of open graded asphalt is by ravelling of the surface aggregate. The life of open graded asphalt using modified binders can be significantly longer than for one using unmodified binder.

The choice between the use of modified and unmodified binders is dependent upon traffic stress and volumes. Polymer modified binders are normal practice for heavier traffic volumes and also achieve greater durability, due to the ability to use thicker binder films and improved binder cohesion.

A detailed guide to the selection and design of open graded asphalt is provided in APRG Report No. 18.

5.5 Stone mastic asphalt (SMA)

Stone mastic asphalt (SMA) has been developed as a fatigue and rut resistant mix. It is designed to have a large percentage of interlocking coarse aggregate (stone on stone contact), with the remaining voids filled with a mastic comprising fines, filler, bitumen and air.

Small percentages of mineral or cellulose fibres are commonly used to minimise the risk of drain down of the relatively high binder content during transport and placing. Polymer modified binders may also be used to reduce the risk of binder drain down, as well as to reduce risk of bleeding under severe performance conditions or to enhance flexibility. SMA mixes are inherently flexible due to the high binder contents.

The compacted SMA mix has a surface texture appearance similar to that of open graded asphalt. This provides noise and skid resistant properties somewhere between dense graded and open graded asphalt. Unlike open graded asphalt, it has a low air void content, and hence good durability.

The combination of stone to stone contact of the coarse aggregate and stiffening of the binder "mastic" with fine aggregate and filler provides a mix with good deformation resistance, making it suitable for use in heavily trafficked situations, including intersections.

Generally SMA is used as a surfacing material in size 7, 10 and 14 mm mixes. Experimental work is being undertaken using size 20mm SMA as a waterproofing layer below open graded asphalt, and as a fatigue layer in modified full depth asphalt pavements. It is too early to comment on the success or otherwise of the use of SMA for pavement layers other than wearing course at this time.

5.6 Fine gap graded asphalt (FGGA)

Fine gap graded asphalt was developed to provide good durability in locations such as residential streets and lightly trafficked roads.

Gap graded mixes are a variation of dense asphalt, but with some aggregate fractions reduced or omitted.

Fine gap graded mixes have a relatively larger proportion of fine aggregate for improved workability and ease of compaction. When combined with a relatively high binder content they can achieve exceptional durability.

Detailed design procedures are published in APRG Report No 18:

5.7 Ultra thin asphalt surfacings including thin open graded asphalt

Thin asphalt surfacings are of two major types:

a) Thin open graded asphalt placed with a modified asphalt paver that applies a binder layer immediately ahead of the asphalt layer, and
b) Modified, small sized, dense graded asphalt mixes.

Thin asphalt surfacings have been developed as a means of restoring surface characteristics of otherwise sound pavements with the shape correction and surface properties of asphalt but with a minimal thickness of asphalt. The treatments provide some shape correction and provide a surface with the properties of asphalt.

The thin surfacings are more economical and more tolerant of surface deflection than thicker asphalt layers, and do not significantly raise levels relative to adjoining surfaces.

In the thin open graded asphalt surfacing system, a polymer modified emulsion binder is sprayed on the surface to waterproof the surface and provide a strong bond for the following thin open graded asphalt layer.

By incorporating the application of binder with spreading of asphalt, asphalt is placed directly on the binder without machinery driving on the binder layer. The finished surface is comparable with a normal open graded asphalt surface, but with reduced water drainage capacity due to the thinner layer.

Small sized dense graded asphalt mixes may be either a standard type grading using a 5 mm nominal size aggregate, modified as a fine gap graded mix, or modified as a coarse gap graded mix somewhat similar to stone mastic asphalt. Small sized, fine gap graded mixes are normally only used for light duty applications such as pedestrian areas, whereas small coarse graded mixes may be suited to higher traffic through greater texture and deformation resistance.

5.8 Asphalt with epoxy modified or polyurethane binders

Specialty asphalt materials have been developed using epoxy modified or polyurethane binders. These cure to provide a surfacing material with exceptional bond strength, toughness, flexibility and solvent resistance.

The extremely high cost of such materials confines their use to specialised applications such as the surfacing of steel bridge decks or other unusual applications in areas of high traffic stress.

5.9 Cement grout filled macadam

Cement grout filled macadam is constructed with a layer of open graded asphalt that is penetrated with a special fluid cement mixture.

The hot mix asphalt base provides a surfacing layer suitable for use on flexible pavements, while the cement mixture provides a surface which is rut and abrasion resistant as well as resistant to spillage of fuels and other solvents.

The surfacings are suitable for industrial applications and transport terminals, where resistance is required to static and slow moving loads, fuel or oil spillage, or surface abrasion.

The products are generally offered as proprietary processes and require skilled installation. Expert advice should be sought before use.

5.10 Recycled asphalt

Asphalt reclaimed from existing pavements can be recycled:

- as a component in the manufacture of new hot mix asphalt
- as cold plant mixed material using a small amount of rejuvenating oil, bitumen emulsion binder or foamed bitumen binder
- cold in place using similar processes to cold plant mixed material
- hot in place.

Hot mix asphalt incorporating recycled asphalt is manufactured to meet the same performance requirements as materials manufactured entirely from new materials.

Cold processes generally require some form of additional surfacing layer and are usually considered as a base course.

Hot in place recycling requires special machinery and techniques, but can achieve an end result comparable to new materials. It can be applicable to correcting shape, ageing effects or surface texture of asphalt surfacing on an otherwise sound pavement.

For further information reference should be made to the AUSTROADS Recycling Guide.

Table 5: Selection of nominal size of dense graded asphalt mix

Nominal size	Typical layer thickness (mm)	Typical use
5	15–20	Available in limited locations for use as very thin surfacing layer with fine surface texture
7	20–25	Commonly used for surfacing residential streets and foot traffic areas where thin layers and fine surface texture required.
10	25–40	General purpose wearing course mix suitable for both light and moderate traffic applications
14	35–55	Wearing course mix for heavier traffic applications. Also intermediate course to suit layer thickness
20	> 50	General purpose base and intermediate course mix for wide range of use.
28	> 70	Less commonly used for base and intermediate course than 20 mm. Control of segregation can sometimes be an issue
40	> 100	Occasionally used as heavy duty base. Control of segregation can be a significant problem

Table 6: Guide to the selection of dense graded asphalt wearing course

Traffic Category [1]	Laboratory Compaction Level	Design Air Voids (%)	Binder (Class/Type)	Recommended use
Light	50 cycles	4.0	170	Residential streets and car parks. Foot traffic.
			320	Sometimes used for above in warmer climates.
Medium	80 cycles	4.0	170	Normal conditions and lower traffic ranges, particularly in cooler regions.
			320	Good general purpose mix for a wide range of applications.
Heavy	120 cycles	4.0	320	General purpose mix for heavily trafficked applications. Generally combined with use of polish-resistant aggregates.
			600, Multigrade or PMB	Higher performance mixes for greater traffic loadings. Stiffer binders require strong, stiff base.
Very heavy	120 and 350 cycles	5.0	320	Heavily trafficked intersections, slow moving traffic, requires coarse grading.
			600, Multigrade or PMB	Special applications such as very heavily trafficked intersections, heavy duty industrial pavements, and aircraft hard standing. Requires coarse grading.

Notes: 1. See Table 7

Table 7: Guide to traffic loading category

Traffic category	Indicative Traffic Volume		Traffic speed
	Commercial vehicles/lane/day	Structural design level	
Very heavy/very high	>1000	> 2 x 10^7	Generally > 25 km/hr
	>500	> 5 x 10^6	Stop/start, climbing lanes or generally < 25 km/hr
Heavy/high	500 to 1000	5 x 10^6 to 2 x 10^7	Generally > 25 km/hr
	100 to 500	5 x 10^5 to 5 x 10^6	Stop/start, climbing lanes or generally < 25 km/hr
Medium	100 to 500	5 x 10^5 to 5 x 10^6	Generally > 25 km/hr
	< 100	< 5 x 10^5	Stop/start, climbing lanes or generally < 25 km/hr
Light	< 100	< 5 x 10^5	Generally > 25 km/hr

6 BITUMINOUS SLURRY SURFACING

6.1 General

Slurry surfacings are of two general types, a basic slurry mixture usually known as slurry seal, and an enhanced mixture that is usually designated as microsurfacing.

6.2 Slurry Seals

The maximum size of materials in a slurry seal varies from sand to size 7. These surfacings are composed of a graded mixture of sand and crushed rock containing filler, cement and unmodified bitumen in an anionic emulsion (at least in the manufacturing stage) and are generally placed in thicknesses around 1 to 1.5 times the nominal mix size.

Slurry seals tend to be very thin (<15mm), have a fine surface texture, and be relatively stiff when compared with asphalt. Because of its fine surface texture, slurry generally provides satisfactory skid resistance at low speeds (< 70 km/hr) but can be unsatisfactory at high speeds (> 70 km/hr). The road environment and geometry needs to be considered carefully when considering the use of slurry seals.

Slurry surfacing must be placed on a sound pavement due to its stiffness and poor resistance to reflective cracking.

Slurries can be used for the correction of minor rutting, provided they are covered by a sprayed seal or asphalt.

6.3 Microsurfacing

Microsurfacing is similar to the slurry sealing process, except that polymer modified bitumen emulsions are used to provide faster setting for earlier trafficking, greater resistance to rutting, greater durability and improved flexibility. Larger sizes of aggregate and multiple applications are also feasible. Microsurfacings are usually based on the use of cationic emulsifier systems. Other terms for microsurfacing include microasphalt, cold overlay and microseal.

The nominal size of microsurfacing is usually in the range of 3 to 10 mm.

Microsurfacings may be used for wearing course applications at nominal depths of around 8 mm, or may be designed for significant shape correction such as wheel rut repair. Polymers are an integral part of these systems, and are used to optimise the mix design for the overlay product.

6.4 Cape seal

Cape seal takes its name from its origin in Cape Province, South Africa. It is constructed by initially spray sealing the pavement (usually using a size 20 mm aggregate) followed by a slurry surfacing which can either partially fill the void space between the bitumen and the top of the aggregate or completely cover the top of the aggregate.

This type of treatment provides a very robust surfacing.

The surface characteristics of cape seal are substantially those of slurry.

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No. 6 Polymer modified binders

No. 7 Treatment of bleeding or flushed surfaces

No. 11 Surface characteristics of bituminous surfacing

No. 18 Sprayed sealing – Selection of initial treatments

No. 19 Sprayed sealing – Selecting aggregate size

No. 25 Geotextile reinforced seals

No. 32 Sprayed seals – A brief description