



mainroads
WESTERN AUSTRALIA

Engineering Road Note 10

Stone Mastic Asphalt

May 2016

Contents

1	INTRODUCTION	3
2	WHAT IS STONE MASTIC ASPHALT	3
3	PROPERTIES OF STONE MASTIC ASPHALT	3
3.1	Fatigue Resistance	3
3.2	Surface Texture and Drainage	3
3.3	Skid Resistance	4
3.4	Road/Tyre Noise	4
4	FACTORS TO CONSIDER BEFORE USE	5
5	APPLICATIONS FOR STONE MASTIC ASPHALT	6
5.1	Noise Reduction – Seal to Asphalt Surface	6
5.2	Noise Reduction – Existing DGA Surface	6
5.3	Skid Resistance at Uncontrolled Intersections	6
5.4	New Construction	7
6	UNDERLYING SEALS	7
7	TIE-IN TO EXISTING ASPHALT	7
7.1	SMA to a Seal	8
7.2	SMA to DGA	8
7.3	SMA to OGA	9
8	REFERENCED DOCUMENTS	11

Document Control

Owner	Manager Materials Engineering
Custodian	Bituminous Products Consultant
Document Number	D16#232643
Issue Date	May 2016
Review Frequency	As required

Amendments

Revision Number	Revision Date	Description of Key Changes	Section / Page No.
0	May 2016	New document	

1 INTRODUCTION

This Engineering Road Note is intended to provide guidance on the selection and use of stone mastic asphalt (SMA) as a pavement wearing course. It provides guidance on skid resistance, types of seal treatments below SMA, tie in to existing asphalt and properties of SMA.

2 WHAT IS STONE MASTIC ASPHALT

SMA is asphalt that has more binder than dense graded asphalt (DGA) and when placed and compacted, 10mm nominal sized SMA has a greater surface texture than a similar sized DGA. SMA has a high proportion of coarse aggregate with some 50% extra coarse aggregate than would a typical dense graded asphalt mixture. When designed appropriately, the high proportion of coarse aggregate interlocks to form a strong skeleton of aggregate. Within the stone skeleton are void spaces that accommodate binder, filler and fine aggregate mixed together to form a mastic. The proportion of filler in SMA is about 10% which is about double that of DGA, and it is important that SMA has a higher binder content to coat the large surface area of the high proportion of fine material in the mastic. This mastic is what provides SMA with improved fatigue resistance. In addition the use of a polymer modified binder also provides improved fatigue resistance. SMA is manufactured with cellulose fibres to ensure that the mastic has sufficient stiffness such that the mastic does not settle in the mixture during transport and placement.

SMA is specified in two nominal sizes of 7mm and 10mm in Main Roads Western Australia Specification 502. The specification includes the properties of the materials used, the properties of the design mixtures, manufacture and testing of mix, transport and placement and conformance testing. Ideally SMA should be placed at a compacted thickness of 4 to 5 times the nominal size of the asphalt mix design. Recommended compacted thickness is 30 to 35mm for 7mm SMA whilst a thickness of 35mm to 45mm for 10mm SMA.

3 PROPERTIES OF STONE MASTIC ASPHALT

3.1 Fatigue Resistance

SMA is asphalt that has a high binder content which along with the use of a polymer modified binder results in an asphalt mix with a higher resistance to fatigue cracking than DGA and open graded asphalt (OGA) even when manufactured with a polymer modified binder. Cracking typically occurs due to damage from repeated traffic loadings either where asphalt has hardened from ageing or where strain has occurred in the wearing course and not in the pavement. Based on overseas feedback and asphalt mix design theory SMA should provide a longer life than DGA before resurfacing is needed with values of 20 to 25 years being suggested. As traffic management is a large component of the cost of resurfacing an extension in the life of the wearing course means less interventions during the life cycle of a pavement. This also benefits road users and the community with less network intervention.

3.2 Surface Texture and Drainage

The 10mm SMA will have a surface texture at construction of the order of 1.2 to 1.4mm on average. This texture reduces marginally in the first 4 years or so and then increases slightly as the binder wears from the surface voids of the SMA. The 7mm SMA has a surface texture at construction of the order of 0.7 to 0.9mm and does not change much in its life cycle. These textures are much lower than those of OGA which has a surface texture at construction of the order of 3.5 to 4mm. The key difference is that OGA is designed to have a high proportion of voids within its stone skeleton (16-21%) and these voids facilitate drainage of surface water down through the entire depth of the OGA. A vehicle tyre can displace surface water under the contact area of the tyre by pushing water down and sideways through the internal voids of the OGA. This reduces the amount of surface water that has to be displaced by the vehicle tyre as water spray when the tyre lifts from the road surface.

The voids in SMA are 3.5-5.5% and its texture comes from the surface voids in the SMA at the time of placement. Hence surface water on SMA has to move sideways across the limited surface voids of the SMA. This means that a vehicle tyre must displace most of the surface water as water spray when the tyre lifts from the road surface. The amount of tyre spray from a SMA surface will be similar to DGA and it needs to be taken into account when considering the use of SMA on high speed roads with high volumes of traffic where vehicle following distances will be closer. Where traffic volumes are of the order of 45,000 AADT and more across 4 lanes it would be preferable to use OGA on a high speed traffic environment.

On high speed roads of 90 km/hr and greater 10mm SMA will provide a higher surface texture than 7mm SMA and is the preferable sized SMA to use in this speed environment. In lower speed environments 7mm SMA will provide sufficient surface texture to be consistent with the advice in the Main Roads document *Guide for Surfacing Type Selection*. There may be situations on high speed roads where the total asphalt thickness has to be limited due to pavement strength or where the new SMA has to tie in to a thin layer of existing asphalt. In these circumstances it may be necessary to use 7mm SMA as 10mm SMA should not be placed at a thickness less than 35mm (refer Section 2). SCRIM testing on Main Roads SMA mixes has shown 7mm SMA to have adequate skid resistance however 10mm SMA should be used on high speed roads to attain a higher surface texture.

3.3 Skid Resistance

SMA provides adequate skid resistance when conforming aggregates are used. As SMA has high binder content the binder film thickness on the larger coarse aggregates, which make up three quarters of the asphalt, is much thicker than DGA. This can result in a small reduction of the skid resistance of SMA in the first months of service. The skid resistance then increases, as the binder film wears off the aggregates as a result of trafficking and weathering. To get the most rapid wearing of the binder from the surface of SMA early in its life it is recommended to place SMA in Spring, Summer and early Autumn when the weather is warm. This ensures the binder is warm to hot which assists in the quickest wearing of binder from the road surface. In the cooler months the polymer modified binder is stiffer and takes longer to wear away so it is recommended to apply a surface grit to provide improved surface friction. The Main Roads document *Initial Skid Resistance of Stone Mastic Asphalt* provides detailed information on this matter and how it can be managed.

3.4 Road/Tyre Noise

Noise from vehicles using a road is the main source of environmental noise on the road network. This noise primarily comes from the sound of vehicle engines, transmission and tyres along with noise generated by surface characteristics of a road such as asphalt joints, potholes or an uneven surface finish. At low speeds noise generated from a vehicle's engine and transmission may be the main source of noise, however as speed increases the noise from the interaction of a vehicle's tyres with the road surface becomes the main source of road noise.

The noise generated will vary depending upon tyre characteristics, whether the road is wet or dry, atmospheric conditions and the type of road surface. This advice will focus on the impact of a road surfaced with SMA. Sprayed seals generate the most road/tyre noise with only marginal difference as to the size or texture of a seal. DGA generates less noise than a seal but more noise than OGA. On high speed roads 10mm SMA generates road/tyre noise similar to DGA whilst 7mm SMA generates road/tyre noise between that of DGA and OGA.

Main Roads has measured the noise generated by SMA and OGA road surfacings on high speed roads over a number of years and this information is available in Materials Engineering Report 2014-14M available with this document on the Materials Engineering Branch page of the Main Roads website. Measurements have not been undertaken at lower road speeds however general feedback is that SMA appears to provide a more comfortable level of noise in a vehicle cabin at lower speeds in comparison to driving on DGA of a comparable age. This may be more so for 7mm SMA than 10mm SMA.

4 FACTORS TO CONSIDER BEFORE USE

SMA is premium quality asphalt that requires good quality and well graded raw materials and a manufacturing plant capable of achieving the required outcomes. At present SMA has only been manufactured for Main Roads in Perth asphalt plants and transported short distances. Many regional or mobile asphalt plants may not be capable of manufacturing SMA at all or to acceptable standards. If considering SMA for a location on the Main Roads network more than 100km from Perth it is recommended that advice be sought from the Materials Engineering Branch. Some factors to consider in choosing to use SMA as a wearing course include:

- **Transport distance** – with long transport the concern is that the binder in the SMA may drain down off the aggregate particles. However with the use of fibres and a polymer modified binder in the SMA the consistency of the mastic is high, reducing the risk of binder drain down. The longest transport distance of SMA has been to Gingin from Malaga without any problems observed and this mix was not produced with a polymer modified binder.
- **Asphalt plant** – some regional plants may not be able to add bag house dust or other fillers into the plant, may not be able to feed fibres and have a binder storage tank that meets the requirements for storage of polymer modified binders. Some mobile plants may be capable of manufacturing SMA.
- **Cost** – SMA in Perth can be of the order of 30% more in unit cost in comparison to supply and lay of DGA, however in theory SMA should achieve a service life longer than DGA justifying the extra cost. This is yet to be proven from the Main Roads SMA mix designs at ground level however laboratory data supports the theory.
- **Workability** – the mastic in SMA makes it difficult to work even in Summer. Therefore SMA should be used where it can be laid in long paver runs with no or minimal hand work in fillets or medians. Another consideration for median areas is to use DGA which facilitates easier hand working. At air temperatures below 25°C SMA has to be manufactured with a chemical additive which improves the workability of the mixture even at the lower temperatures. If intending to place SMA in the coldest time of the year tightened work practices need to be implemented by the asphalt supplier to ensure the mix is placed to achieve a good surface finish with conforming compaction. Tightened work practices may include manufacturing the SMA at the upper temperature level specified, reducing output to ensure rollers have sufficient time to achieve surface finish and compaction, using heavy rollers and using a materials transfer vehicle to achieve even temperature distribution.
- **Widening works** – a key consideration is that SMA, like wearing course DGA, is permeable in that water can find its way down through the layer of SMA to an underlying seal coat or an underlying layer of DGA. Therefore, for a granular pavement scenario, when matching the profile of a new SMA wearing course to that of existing asphalt it is vital that an underlying waterproofing seal be in the same plane as the seal below the existing DGA. Section 7 will provide further advice along with drawings and options for placing SMA adjacent to an existing seal, DGA or OGA.
- **Cooling Before Trafficking** – SMA has a high binder content and only steel wheeled rollers are used during placement. Similarly it is important that rubber tyred vehicles are not allowed to drive on freshly laid SMA whilst it is warm to hot. Specification 502 requires that SMA be cooled to a surface temperature of less than 63°C before it is opened to traffic. This needs to be considered for works that may require early trafficking such as a traffic switch to a new carriageway or resurfacing works under traffic.

5 APPLICATIONS FOR STONE MASTIC ASPHALT

5.1 Noise Reduction – Seal to Asphalt Surface

Overlaying a seal with DGA or SMA will significantly reduce road/tyre noise. In this circumstance on roads with speed limits of 90 to 110 km/hr it is recommended to use 10mm SMA to achieve the highest surface texture. If the speed limit is 80 km/hr or less either 7mm or 10mm SMA or DGA will suffice however 7mm SMA will achieve more effective noise reduction than either a DGA or 10mm SMA. These recommendations are subject to the sealed pavement having adequate stiffness to support an asphalt wearing course without premature failure.

Examples where sealed roads have been changed to SMA include Tonkin Hwy near Maddington Rd, Great Eastern Hwy at Sawyers Valley, Marmion Ave at Sorrento, Roe Hwy at Maida Vale and Bellevue and the Melville-Mandurah Hwy near Secret Harbour. Three of those sites are high speed zones where it is recommended to use 10mm SMA. On Marmion Ave the speed limit is 70 km/hr and it is suggested to use 7mm SMA to achieve the most effective reduction in tyre/road noise and also place an asphalt that has the highest resistance to fatigue failure in a laboratory environment in comparison with DGA or 10mm SMA.

5.2 Noise Reduction – Existing DGA Surface

Resurfacing an existing DGA surfacing with SMA will not achieve significant reduction in road/tyre noise. The new SMA will generate less noise than the old DGA however any comparison of noise should be made against new surfacings of each type of asphalt. In any speed environment 10mm SMA is likely to generate a comparable level of road/tyre noise as new DGA whilst for high speed environments 7mm SMA should generate less road/tyre noise than DGA.

Examples where DGA has been resurfaced with SMA on the Main Roads network are Leach Hwy in Myaree and Albany Hwy in Kelmscott. These sites were the first two applications of SMA by Main Roads which were placed primarily for research purposes. Both sites are low speed environments so there is no benefit in terms of road/tyre noise. In terms of lifetime of the asphalt the theory is that SMA should offer a benefit over DGA.

The 7mm SMA can be laid at a thickness of 30mm making it viable for use in resurfacing many of the lower speed roads on the Metropolitan network. Two key considerations is that it must not be placed on a fresh C170 bitumen seal and where there is any chance of a basecourse being exposed during cold planning operations SMA must not be placed unless there is a constant waterproofing membrane under the SMA. Therefore resurfacing with SMA may have to be done on the full width of a carriageway such that the road profile may be able to be raised to ensure there is a constant waterproofing membrane under the SMA.

At traffic controlled intersections vehicles stopping and starting are more likely to be the predominant source of noise rather than road/tyre noise so the type of asphalt at intersections should remain as 14mm Intersection Mix.

5.3 Skid Resistance at Uncontrolled Intersections

At uncontrolled intersections on high speed sealed roads where it may not be practical to apply or maintain a High Stress Seal the use of 10mm SMA rather than DGA has the benefit of achieving a road surface with texture in excess of 1mm. This recommendation is subject to the sealed pavement having adequate stiffness to support an SMA wearing course without premature failure. The typical design for SMA being laid over an existing sealed surface is shown in the *Asphalt Construction Drawings* available on the Main Roads website.

Examples where 10mm SMA has been used at uncontrolled intersections on high speed roads includes:

- Toodyay Rd entrance to Hanson Quarry
- Great Northern Hwy North of Apple St and Wandena Rd North of Bullsbrook
- South Western Hwy at two intersections South of Karnup.

5.4 New Construction

Subject to a new pavement having adequate stiffness to support an SMA wearing course for the design traffic loading and the SMA meeting any design standards for environmental noise the use of SMA as a wearing course should be considered in preference to DGA. Sections 3.2 and 3.4 provided detail on where OGA should be used and the use of SMA in these environments is not recommended.

An example of new construction is Wanneroo Rd near Ocean Reef Rd where a new carriageway was constructed with a granular pavement which was sealed with a prime and 10/5mm two coat emulsion seal. Size 7mm SMA was placed on the new carriageway as the wearing course whereas in the past a new pavement would have been surfaced with DGA. As the speed zone is 70 km/hr the use of SMA is unlikely to offer any benefit in noise reduction however feedback is that SMA may provide improved ride comfort. SMA does potentially offer a longer lifetime than DGA resulting in less network interruption.

6 UNDERLYING SEALS

Experience has shown that where SMA has been placed over a newly sprayed seal using C170 bitumen it increases the likelihood that flushing may occur in the SMA. This applies to a normal seal or even a geotextile reinforced seal (GRS) when C170 bitumen is used. Flushing has not been observed placing SMA over older bitumen seals or initial seal treatments using bitumen emulsion. Experience with applying SAMI seals has shown that a S20E binder with 10mm cover aggregate and a 14/7mm double/double seal using a S45R rubber binder has shown no evidence of flushing in the SMA. The use of modified binder with higher viscosity reduces the likelihood of the binder in the seal being drawn into the SMA resulting in flushing.

Where a GRS is being used as a SAMI seal the use of C170 bitumen as the seal binder is not recommended. The use of a 5% by mass rubber binder manufactured in a high shear mill without blending oils provides a binder with a higher viscosity yet can be applied to all layers of a GRS covered with a 14/7mm seal. Because the 5% rubber binder is more viscous a GRS treatment with this modified binder must only be done when road temperatures are warm to hot.

7 TIE-IN TO EXISTING ASPHALT

Section 4 raised the issue of using SMA as the wearing course for a pavement widening. It is important water does not enter a granular pavement via a poorly designed joint between new SMA and existing asphalt. Similarly because of the different surface drainage characteristics of SMA the flow of surface moisture between SMA and existing DGA or OGA be taken into consideration in designing the construction of a new pavement surfaced with SMA or resurfacing with SMA.

This section provides examples using drawings of how SMA should be joined with other road surfacings along with recommendations. The Asphalt Construction Drawings available on the website has Standard Contract Drawing Number 201331-0037 which shows transverse joints between SMA and a sealed pavement and a pavement surfaced with DGA.

7.1 SMA to a Seal

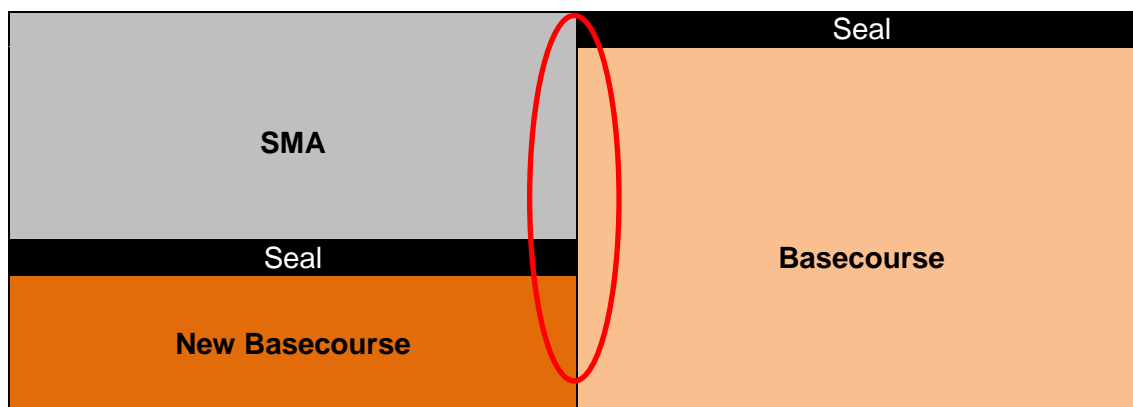


Figure 1

If a seal is to remain as part of a widened pavement Figure 1 shows a possible longitudinal joint between the existing and new pavement. The highlighted portion of Figure 1 shows the zone where moisture permeating down or through SMA can enter the pavement basecourse which will reduce the strength of the basecourse material. It is not possible to achieve total waterproofing of the vertical interface between the SMA and existing basecourse. Therefore where SMA is considered for widening of a pavement SMA should be used to overlay the full width of the new and existing pavement as shown in Figure 2. A transverse joint between the SMA and the seal should be constructed as shown in Standard Contract Drawing Number 201331-0037.

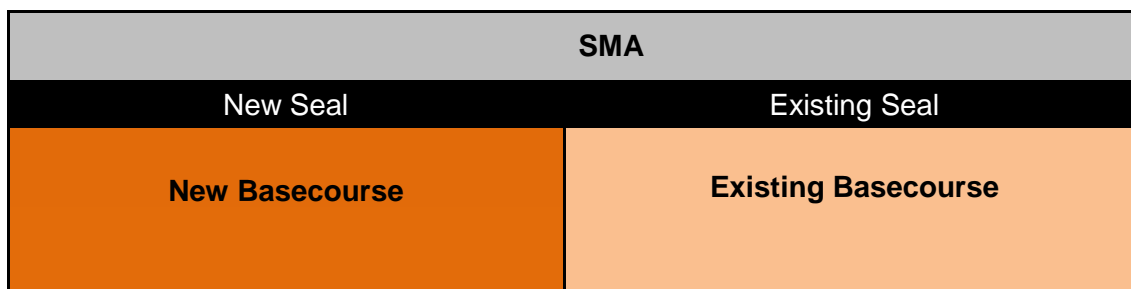


Figure 2

7.2 SMA to DGA

Some considerations to take into account in planning to use SMA as a wearing course on widening of an existing granular pavement surfaced with DGA include:

- Thickness of the new and existing asphalt should be consistent for future resurfacing.
- The seal in the widening work should be on the same plane as the seal in the existing pavement.
- SMA should not be placed on the higher side of the cross fall where water will pond on the joint against the DGA.

These are highlighted in the following figures.

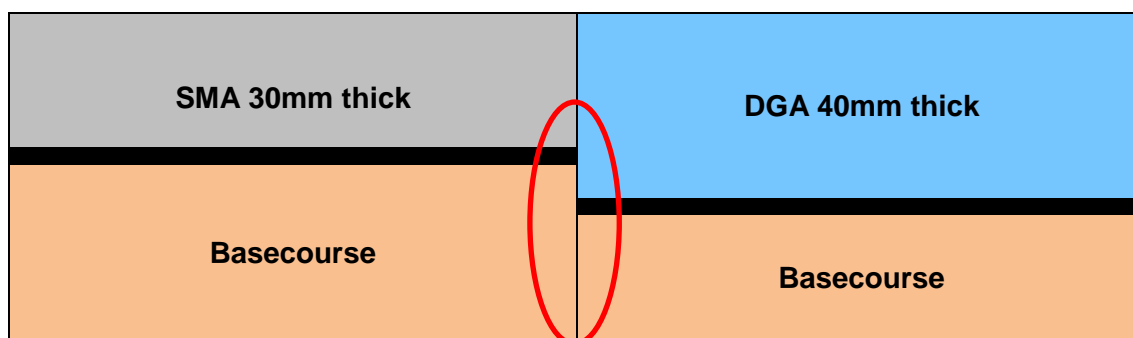


Figure 3

In the example at Figure 3 asset maintenance planners may not be aware of differences in the depth of the SMA and DGA and program resurfacing works to remove 35mm of asphalt by cold planning based on the known thickness of 40mm. The consequence is exposure of the basecourse below the SMA. The resurfacing works may include a SAMI seal however this will not bond to the basecourse surface resulting in the basecourse not being protected by an effective waterproof seal. Figure 3 also shows the impact of placing SMA on the high side of the cross fall where water can pond against the edge of the DGA.

Figure 4 shows one option for managing this risk which would require 10mm SMA to be placed at 40mm thick. As mentioned above this is still problematic, where SMA should not be placed on the high side of the cross fall. To overcome this and create a consistent thickness in the depth of asphalt an option is to construct the new basecourse and waterproofing seal to the same plane as the existing seal, remove the existing DGA, apply a SAMI seal and place 30mm of 7mm SMA over the entire width of the road including the new work. This option has the advantage of reducing the total thickness of asphalt over a granular pavement. Both of these options provide a consistent thickness of asphalt reducing the risk of damage to the waterproofing seal during future resurfacing work.

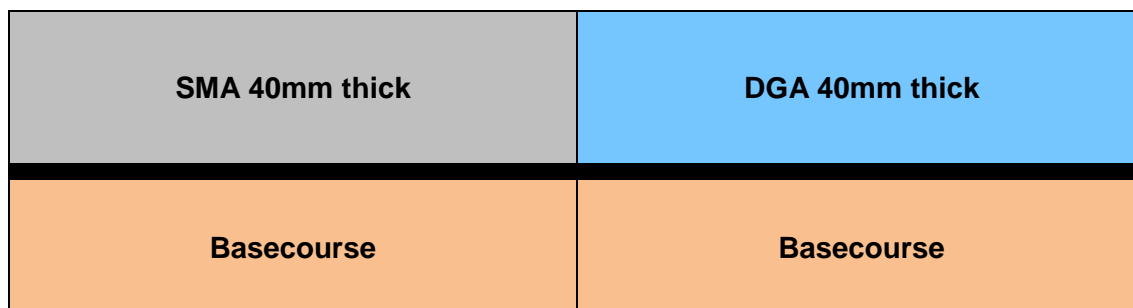


Figure 4

Where the new SMA is likely to be greater in thickness than the existing asphalt construct the new basecourse and seal to the plane of the existing basecourse and seal, remove the existing asphalt by cold planing, apply a SAMI seal as necessary and resurface with SMA for the full width of the carriageway. The outcome is shown in Figure 2.

7.3 SMA to OGA

In planning to match SMA against OGA as wearing courses the type of pavement needs to be considered. Where the existing and new pavements are both an asphalt pavement then movement of surface water is the key factor. The asphalt pavement would be constructed to achieve a construction joint similar to that shown on Standard Contract Drawing Number 201331-0038 where the SMA or OGA would overlap the new or existing pavement and a waterproofing seal would eliminate entry of moisture into the pavement.

However where SMA is placed on the lower side of the crossfall SMA does not have the same level of internal air voids as in OGA so it will interfere with the sideways movement of water at the edge of the OGA. Therefore SMA should only be used on the high side of the crossfall or the entire width of a carriageway must be resurfaced with SMA.

Where the SMA is placed on a new granular pavement as shown in Figure 5 it would be expected that the profile of SMA match that of the adjacent OGA, however this creates a problem in matching levels of the waterproofing seal and surface of the basecourse on the existing and new work. The highlighted portion of Figure 5 shows that water can enter the pavement basecourse through the construction joint or through the DGA layer below the OGA wearing course. This water will reduce the strength of the basecourse material resulting in fatigue failure of the asphalt and loss of service of the road through cracking and further moisture ingress.

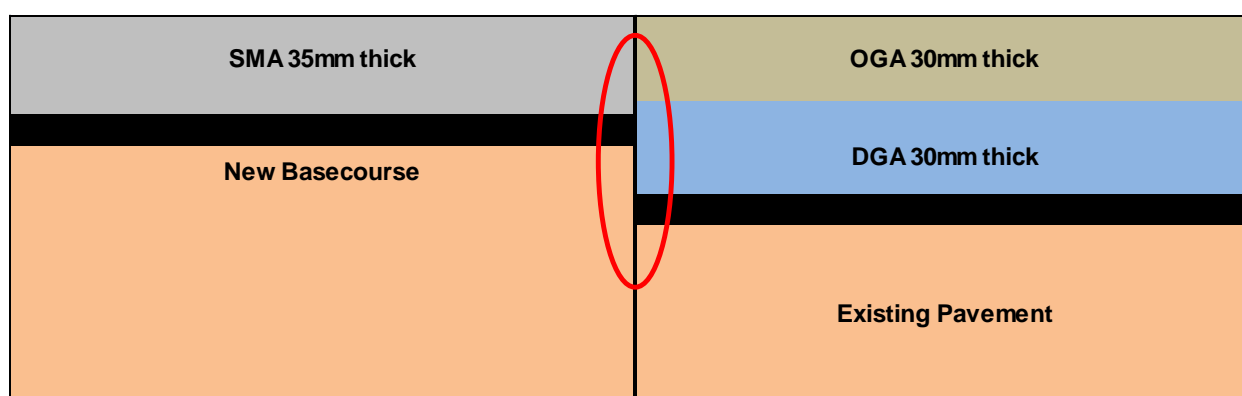


Figure 5

Where SMA is to be used for widening of a pavement then the full width of the new and existing pavements should be surfaced with SMA. In this situation the new basecourse should be constructed to 45mm below the surface level of the OGA, similar to the layout shown in Figure 5. The basecourse will be sealed using a prime coat and a double/double 10/5mm emulsion seal. The existing OGA and DGA will be cold planed to a depth of 35mm (see Figure 6) ready for the application of a SAMI seal and full width placement of SMA (see Figure 7).

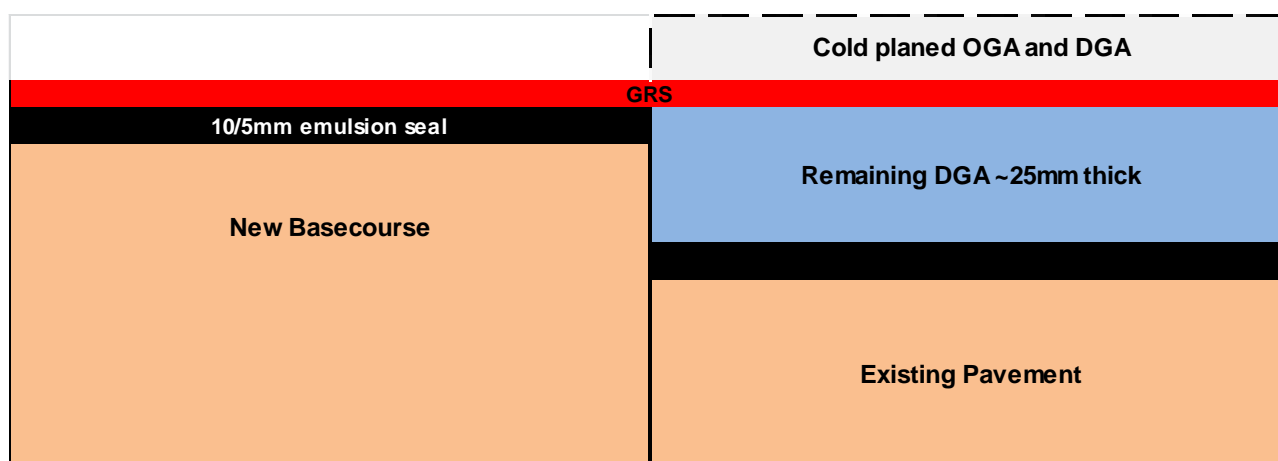


Figure 6

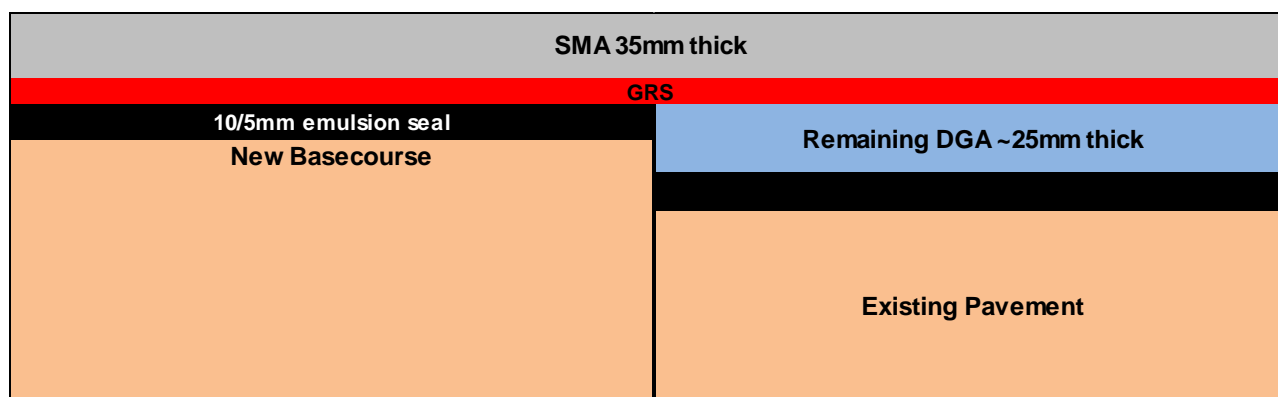


Figure 7

Where the SAMI seal is a S20E binder then a paving tape shall be applied over the emulsion seal and cold planed DGA spanning the construction joint (see Figure 8). Where a geotextile reinforced seal (GRS) is used as the SAMI seal then the paving tape can be excluded. Refer to Section 6 for advice on seal binders to be used underneath SMA.

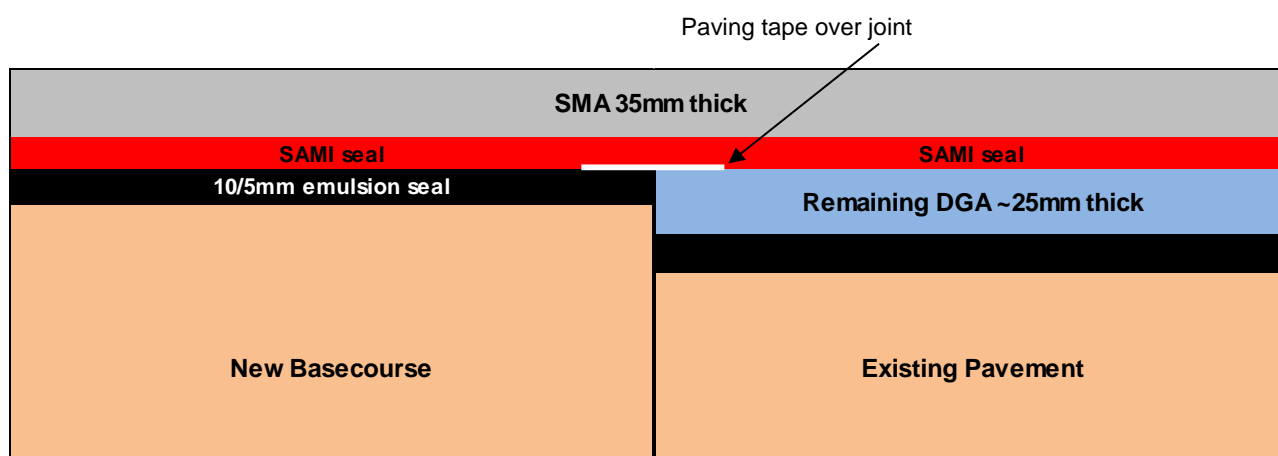


Figure 8

8 REFERENCED DOCUMENTS

Document Number	Description
6706-04-154	<i>Guide for Surfacing Type Selection</i> , Main Roads Western Australia 2004
71-06-1359	<i>Initial Skid Resistance of Stone Mastic Asphalt</i> , Main Roads Western Australia 2010.
Materials Engineering Report 2014-14M	<i>Tyre Road Noise of Open Graded and Stone Mastic Asphalt in Perth, 2014 Review</i> , Main Roads Western Australia
Standard Contract Drawing Numbers 201 331-0037 and 201331-0038	Asphalt Construction Drawings, Main Roads Western Australia
Specification 502	<i>Stone Mastic Asphalt</i> , Main Roads Western Australia 2016