ADEPT

The Association of Directors of Environment, Economy, Planning & Transport

Guidance on resilience of surfacing materials

March 2024

Produced by ADEPT Soils & Materials Design & Specification Group representatives

Cover page image - Design Mix HRA with coated chippings laid in 1991

This briefing note summarizes the salient features of available bituminous materials/treatments in terms of resilience.
It is intended to provide guidance to designers on how to make their asphalt surfaces more resilient under the effects of climate change, which primarily gives rise to hotter and drier summers and more frequent and heavier rainfall in winter. The former increases the risk of surface deformation and accelerated binder ageing, the latter increases the risk of water damage.
The following charts give an indication of relative performance in these specific areas as judged by Senior Road Engineers from ADEPT. By necessity these have to be general values and supplier and geographical differences may change ranking. It is assumed throughout that the asphalt/treatment has been laid using best practice and following the most up to date version of BS 594987.

Asphalt resilience (1 – low 5 – high)

material	Cost/ tonne	Warm weather events		Wet weather events	Overall resilience
		Warm temp deformation resistance	Resistance to Binder aging	Resistance to Aggregate loss/ fretting/pot holes	
HRA + CC	4	1	4	4	4
HRA (SBS Heavy polymer)+CC	5	4	5	4	5
High Stone Asphalt	2	3	3	3	3
Dense SMA	3	3	4	4	4
TS2010/WG SMA	4	4	5	5	5
TSCS	2	3	3	2	3
AC surfacing	1	2	2	2	2
AC binder course	1	3	N/A	N/A	3
SMA binder course	2	4	N/A	N/A	4

Surface treatment resilience

material	Warm weather events		Wet weather events	Overall resilience
	Warm temp stability	Resistance to Binder aging	Resistance to Aggregate loss/ fretting/pot holes	
[1]Surface Dressing	3	2	3	3
Microsurfacing	4	3	4	3.5
Preservation	3	2	4	3
Cauts	4	3	4	3.5

[1]– made with polymer emulsion binder.

In the UK extreme cold weather events are perhaps reducing so not specifically highlighted however it is worth noting that the properties that give resistance to wet weather events also provides resistance against freeze thaw damage.

Further information on the failure modes of road materials is given in the ADEPT Selection of surfacing for highways document.

ADEPT CSS Research Project 78 contains detailed information about climate change and resilience. Appendix 3 contains detailed information about asphalt materials, in situ recycling and patch repairs.

The MCHW is currently being revised by National Highways. Clause references are to the pre 2025 version.

Each of the following sections provides additional details around the specific mixtures as well as more specific references that relate to the asphalt mixture under discussion.

References -
ADEPT CSS Research Project 78 Climate Change and Evolved Pavements. 2011
ADEPT Selection of surfacing for highway pavements Rev 5 2014
BS 594987 Asphalt for roads and other paved areas – Specification for transport, laying, compaction and product-type testing protocols
PD 6691 Guidance on the use of BS EN 13108, Bituminous mixtures (British Standards).
The Design Manual for Roads and Bridges (DMRB) in particular CD225 and CD239
The Manual of Contract Documents for Highway Works (MCHW), in particular the 900 series.
TRL Report PPR 184 The effects of climate change on highway pavements and how to minimise them: Technical report 2008
TRL Report PPR 233 Sustainable choice of materials for highway works: a guide for Local Authority highway Engineers 2008
PIARC Measures for Improving Resilience of Pavements. A PIARC Technical Report 2023

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HRA with coated chippings has been used as a surface course for more than 60 years and has a proven record of durability when laid using best practice. HRA mixtures designed to receive coated chippings are made with a uniformly graded coarse aggregate, usually 14 mm, the amount of coarse aggregate is usually 30 or 35%. The fine aggregate should be predominantly a uniformly graded rounded sand to allow successful chipping embedment which, with the binder and filler, forms a mortar to envelop the coarse aggregate. The binder grade is almost always 40/60 pen or a SBS polymer-modified binder [PMB] for heavily trafficked installations.
The chippings are usually 20 mm nominal size and made of appropriately skid resistant aggregate. Because high skid resistance aggregate is only used for the chippings using HRA helps to conserve stocks of this valuable resource. The chippings provide a high surface texture so that HRA can be used on high speed roads, but the high texture means that more tyre noise is generated and spray from tyres during wet weather significantly affects visibility.

HRA requires experienced surfacing operatives, especially when it is made with PMB, and laying in cold or wet weather should be avoided. It requires a wider operational area for laying to allow consistent feed to the chip spreader.

HRA surface course comes in 3 forms, performance, design and recipe. Recipe mixtures are more suitable for lightly trafficked roads as they often contain more binder than design mixtures and hence have improved durability.

Unmodified HRA surface course has low rut resistance. Design mix optimises binder content for strength but does not necessarily improve rut resistance. Performance mixes made with polymer additive should be used for slow moving traffic and heavily trafficked lanes as the polymer significantly elevates the softening point of the bitumen giving better high temperature deformation resistance.

With predicted higher surface temperatures it is likely that increased use of PMB will be necessary to ensure HRA has adequate rut resistance.

HRA has higher crack resistance and is more flexible than other surface course materials and both properties are also further enhanced by using a suitable elastomeric PMB binder such as a SBS modifier. This also makes HRA more resistant to road foundation disruption caused by flooding or drought. HRA has low voids and a thick mortar making it very resistance to moisture damage and more resistant to damage from flooding events.

Specification guidance -
PD 6691 Annex C, Section C2.5 and Table C2. 40/60 pen binder. Table C4 can be used to specify resistance to permanent deformation(rutting).
MCHW Clauses 910 (recipe), 911 (design) and 943 (performance).

References -
PD 6691– Annex C section C.2.5.
ADEPT selection of surfacing - Sections 2.3 and Section 6.2.

ADEPT CSS Research Project 78 - Appendix A3 section 3.
MCHW Clauses 910 (recipe), 911 (Marshall design) and 943 (usually polymer designed to meet wheeltracking requirements)

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HSA has been in use for many years as a durable surface course. HSA contains 55% coarse aggregate, meaning that some coarse aggregate is available at the surface, so that precoated chippings are not applied. The coarse aggregate size can 10 mm or 14 mm in standard mixes. The fine aggregate can be Type F or Type C. Type F is a finer (smaller) grading and sand is commonly used. Type C is coarser and is more frequently made from crushed rock. The binder grade used to make HSA is usually 40/60 pen.

HSA made with sand fines generally has lower skid resistance because it has low surface texture and sand is not usually a high skid resistant aggregate. Sand fines HSA is generally prone to rutting, a polymer modified bitumen can be used to prevent this at increased cost. However, sand fines HSA is usually denser and more water resistant.
HSA made with crushed rock fines can be made entirely of high skid resistance aggregate and has a surface texture similar to that of asphalt concrete surface course. Crushed rock HSA is more rut resistant than sand fines HSA but is less dense, though still quite water resistant and durable.

There is currently no maximum void content requirement in PD 6691 for HSA mixtures but the required aggregate gradings for coarse and fine aggregate should mean that voids are generally low. The binder content of HSA is always determined by a design process described in BS 594987 Annex H.

Resistance to permanent deformation (rutting) can be specified by referring to a class selected from PD 6691 Table C.4. The highest available class should be selected unless the surface is only lightly trafficked.

The low texture of either Type C or Type F means HSA is not suitable for high speed roads.

Depending upon the sand/aggregate sources selected, some mixtures can be prone to segregation.

HSA of either type can be expected to be more durable than asphalt concrete surface course and is more resistant to moisture and occasional inundation. HSA Type F is likely to perform better and provide more protection to the lower layers but offers less skid resistance.

Specification guidance -
MCHW Clause 911
BS EN 13108-4
PD 6691 Annex C section C.2.5.

References-
ADEPT selection of surfacing - Sections 2.3.
ADEPT CSS Research Project 78 - Appendix A3 section 4.

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SMA was originally devised in Germany as a highly durable surface course expected to last 25 years or more.

To achieve this the original specification required a high minimum binder content, the addition of cellulose fibres to retain the binder during transportation and laying, a maximum void content, and limestone, or hydrated lime filler to improve adhesion between the aggregate and binder. Filler is very fine aggregate smaller than 0.063 mm. The binder grade used to make SMA is usually 40/60 pen but 100/150 pen is also used on lightly trafficked roads as it has improved durability compared to Asphalt Concrete or TSCS.

Examples of current specifications that follow this example include Transport Scotland's TS 2010, the Welsh Government's PAG 112/20, and the variants used by County Councils based upon Staffordshire County Council specification 971AR.

In spite of being used in some parts of the UK for many years it may be difficult to procure this material in other areas. The material uses conventional raw materials and admixtures and so should be relatively easy to manufacture. Some producers have products designated as 'heavy duty' or 'industrial' that are similar.

The material has low voids and relatively low texture, but TS 2010 has demonstrated the skid resistance should still be adequate for all levels of traffic.
In early life the skid resistance can be low, this can be addressed by the application of lightly coated grit during installation.
The material is quite rut resistant but may require the addition of a polymer bitumen modifier in very heavily trafficked situations. Resistance to permanent deformation can be specified through PD 6691 Table D.2.
When made as described and laid according to best practice this material should be at least as durable as HRA with coated chippings.
It is resistant to intermittent inundation and is resistant to high surface temperatures.

Specification guidance -
PD 6691 Annex D. 40/60 pen or polymer modified binder. Table D.2 can be used to specify resistance to permanent deformation(rutting).
Transport Scotland TS 2010.
Welsh Government PAG 112/20
Staffordshire CC 971AR

References -
PD 6691– Annex D section.
ADEPT selection of surfacing - Sections 2.2 and Section 6.1.
ADEPT CSS Research Project 78 - Appendix A3 section 6 (some of the information in this document may be out of date)

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TSCS are proprietary materials that meet the requirements of Clause 942 of the MCHW. All TSCS have undergone a System Installation Performance Trial (SIPT) to demonstrate that the material meets the requirements of Cl 942. The SIPT is independently assessed. TSCS are guaranteed for 5 years.

A consequence of this approach is that the constituents of these materials vary, although they are required to meet either BS EN 13108 part1, part 2, or part 5. They all have good texture depth and are suitable for laying on high speed roads. The do have a required minimum binder content, depending on the base specification. They should be laid according to the manufacturer's Installation Method Statement by an approved installer.

Resistance to permanent deformation (rutting) can be specified by referring to a class selected from PD 6691 Table B.4 or Table D.2 as appropriate. The highest available class should be selected.

There is currently no maximum installed void content requirement within the specification for TSCS and durability may be variable as higher voids allow water to penetrate the surface and degrade the adhesion between aggregate and binder.

The durability of TSCS was the subject of a study by the Transport Research Laboratory (TRL). The results can be found in TRL Report TRL674.

Specification guidance -
MCHW Clauses 942.
BS EN 13108-1
BS EN 13108-2
BS EN 13108-5

References
ADEPT selection of surfacing - Sections 2.1 and Section 6.1.
ADEPT CSS Research Project 78 - Appendix A3 section 5. (Note the requirements of Clause 942 have changed since this document was written)
TRL Report TRL674 Durability of thin asphalt surfacing systems. Part 4: Final report after nine years' monitoring 2010

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Asphalt concrete surface courses have traditionally comprised well graded aggregate with relatively low binder content compared with other generic asphalt materials. Until 2007 and the publication of European Standards, they were known as bitumen macadam.

For roads there 2 main divisions of this product, open graded and close graded, both available as 14 mm or 10 mm materials. 6mm dense surface course can be regarded as close graded.

Open graded

Less durable than most other asphalt mixtures because of the thin bitumen coating on the aggregate and the high void content that allows easy access for air and water. Because of this the material is only suitable for very lightly trafficked roads not subject to flooding.

Can be used as part of a drainage solution such as SUDS, in conjunction with a porous base, due to the high void content that allows some water to pass through.

Moderate rut resistance that can be enhanced using polymer modified bitumen binder which will also improve durability. Other ways to improve durability are to apply an asphalt preservative system at regular intervals, or to add extra binder with fibres added to retain additional binder.

Some asphalt producers may have proprietary products that have a porous structure, and porous asphalt to BS EN 13108-7 could be considered as an alternative.

Close Graded

More durable than open graded but still less durable than some asphalt mixtures because of the relatively thin bitumen coating on the aggregate. Because of this the material is only suitable for light to moderately trafficked roads not subject to flooding and not requiring high texture depth.

It is relatively low cost compared to SMA, TSCS and HRA and its life can be extended using conventional treatments such as surface dressing, slurry surfacing or microasphalt.

The material has moderate rut resistance that can be enhanced using polymer modified bitumen binder which will also improve durability.

Other ways to improve durability are to apply an asphalt preservative system at regular intervals, or to add extra binder although this last might reduce rut resistance. Many asphalt producers have proprietary AC products that may incorporate increased binder content.

Specification -
PD 6691 Annex B Section B3.5 and Tables B13, B14 and B15. 100/150 pen binder. With increasing surface temperatures 70/100 pen binder may be more suitable particularly in the South of England.
With increased rainfall the use of an adhesion agent with igneous rock aggregate is strongly recommended unless additional binder is used.
Note AC6 medium surf and AC 4 fine surf are not suitable for roads.
MCHW Clauses 909 and 912.

References -
PD 6691– Annex B section B3.5
ADEPT selection of surfacing - Sections 2.4 and 6.3.
ADEPT CSS Research Project 78 - Appendix A3 section 7.
CIRIA SuDS Manual C753 has information on suitable surfacing materials

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Surface Dressing is a process where the road surface is treated with bitumen emulsion (usually polymer modified) and surface applied aggregate chippings. There are a number of types with different binder and chippings combinations. The design process and types of surface dressing are detailed in TRL Road Note 39. Among other safety related benefits this process seals the road surface protecting it from water damage.

References-
TRL Road Note 29 7th edition Design guide for road surface dressing 2016
RSTA ADEPT Code of Practice for Surface Dressing 2018
PD 6689:2017 Surface Treatments – guidance on the use of BS EN 12271 and BS EN 12273
BS EN 12271 Surface Dressing - Requirements
ADEPT selection of surfacing for highway pavements - Section 2.7
ADEPT CSS Research Project 78 - Appendix A4 section 2.
SHW Cl 919 (recipe) and 922 (design)

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Microsurfacing is the process of mechanically screeding on a mixture of aggregate and (usually polymer) bitumen emulsion. As well as some reprofiling of the road surface this material seals the road surface protecting it from water damage.

References -
PD 6689:2017 Surface Treatments – guidance on the use of BS EN 12271 and BS EN 12273
BS EN 12271 Surface Dressing - Requirements
ADEPT selection of surfacing for highway pavements - Section 2.7
ADEPT CSS Research Project 78 - Appendix A4 section 2.
SHW Cl 919 and 922
RSTA ADEPT code of practice for slurry surfacing including Microsurfacing 2018
SHW Cl 918

A sprayed product is applied to the road surface to provide a protecting layer to slow down oxidation and embrittlement. With non-porous materials the surface can also be sealed protecting it from water damage.

References -
RSTA Road Surface Treatment Handbook
RSTA ADEPT code of practice – Asphalt Surface Course Preservation Treatments 2020
SHW Cl 950

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Cold applied ultra-thin surfacing consists of aggregate bound in a polymer emulsion bitumen. This process seals the road, protecting it from water damage.

References -
SHW Cl 923