Delivering a safe and sustainable highway network

County Road Construction Strategy – 2015

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Approved for use July 2015 **Graeme Fitton** Head of Highways and Transport

This strategy shall be implemented by the Communities Group with immediate effect

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0 Background

0.1 The strategy was last fully revised in 2009

0.2 The strategy covers the construction, structural maintenance and resurfacing of the highway network together with footways, cycleways and cycle paths and associated untrafficked but surfaced areas. It does not include the construction and maintenance of bridges.

0.3 This is an amended version of the 2009 strategy to take into account changes to the Specification for Highway Works up to December 2014, Design Manual for Roads and Bridges, and IANs and the introduction and amendment of EN standards. There is a significant emphasis on safety, sustainability, environment and minimisation of resource use. This is achieved by, in order of priority:

- Reducing and optimising material usage over the long term (greater than 40 years)
- Reuse of the road structure
- Reusing and recycling road materials

0.4 Material usage can be reduced by using thinner but stronger constructions, longer life construction, more durable materials and processes and ensuring construction processes optimise the performance of any material used in the construction. It can also include a reduction in the use of high cost materials where cheaper alternatives will perform sufficiently well.

0.5 The road structure can be reused optimally by timely surface treatments which prevent deterioration of the existing structure. This can include resurfacing with structurally competent materials to extend the design life of the structure or resurfacing with systems that keep water out of the pavement. This maintains the integrity of the structure and prevents foundation weakening or the stripping of binder from aggregate that can occur as binder is exposed to air and water.

0.6 Materials can be recycled either in situ or ex situ but the former minimises haulage of materials away from and return to site. Recycling should only be resorted to after reuse of the structure has been proved to be not feasible. The need for more than local reconstruction is an indication that there has been a failure in the management of maintenance (in a few cases this may be unavoidable due to lack of funds). Failure may be due to lack of timely maintenance or the depredations of those who dig holes in roads to obtain access to services. Any failure is speeded up by the poor maintenance of drainage systems.

0.7 The main changes are to the specification of bituminous materials, the mandatory use of CE marking resulting from the introduction of the Construction Product Regulations (CPR) which has replaced the CPD. A section on bridge deck surfacing is included in chapter 10.

Layout and use of this strategy document

0.8 The document is divided into 21 chapters in 3 parts, together with 3 annexes. Part 1 covers new construction, Part 2 covers maintenance and part 3 includes additional specification clauses and drafts of relevant appendices in the 7/xx series. The chapters are, as far as possible, freestanding and for any process such as resurfacing only one section usually needs to be referred to and there is inevitably a degree of repetition as a result. The annexes cover the specification of Warwickshire special materials which are not specified in nationally available standards or specifications. Other Annexes cover the likely changes in the next few years as a result of changes to external specifications and standards that are expected to be implemented in the near future, the specification for a number of asphalt mixes such as 45/10F in EN 13108-4 format and a list of abbreviations and acronyms.

0.9 There are also a number of supporting papers, held centrally. They include papers on:

- Polished stone values and effect of aggregate size
- Effect of ride quality on pavement life
- Noise
- Structural contribution of thin surfacing

- Patching – causes and investigation of reasons for its need
- Environmental assessment of maintenance operations
- HAPAS system and use of certificates (BBA is no longer the required supervisor of HAPAS requirements but currently all HAPAS certificates have been issued by BBA)
- Reasons for changing the sub-base specification

0.10 Wherever possible existing national specifications and standards are used in preference to specifically local ones. The main ones that are used are:

- Specification for Highway Works volume 1 – Specification
- Specification for Highway Works volume 2 – Notes for Guidance
- Design Manual for Roads and Bridges – volume 7; Pavement Design and Maintenance including several IAN's (interim advice notes)
- BS EN 13108 Bituminous mixtures – material specifications
- BS PD 6691 Guidance on the use of BS EN 13108
- BS 594987 Asphalt for roads and other paved areas – Specification for transport, laying and compaction and type testing protocols.
- IAN 96: Bridge deck surfacing
- Road Note RN42: Best practice guide for durability of asphalt pavements
- HAPAS guidelines and certificates (currently only BBA produces guidelines)
- Well Maintained Highways – Code of practice for highway maintenance management
- ADEPT advice
- Local Transport Note 01/07 Traffic Calming [DfT]
- Manual for Streets 2007 [DfT]

Other standards and specifications will be referred to where needed and a full list is given in the Chapter 20.

0.11 Warwickshire County Council policies and strategies which are relevant to this document are:

- Warwickshire Highway Maintenance – Policy Document
- Road Safety Strategy
- Transport and Roads for Developments: The Warwickshire Guide 2001 (available from Development control)
- Local Transport Plan (LTP)
- Transport Asset Management Plan 2011

0.12 The strategy document is divided into chapters which may be updated independently. The date at which the individual chapter was last revised is included at the end of that chapter. The master document is kept on the WCC system. The currency of the section must always be checked before use. The frequency of updating will vary from section to section but the document will be reviewed on an as needs basis but any sections influenced by the publication of relevant external or internal documents will be revised as required. For example the Specification for Highway Works may be revised every three months although the relevant 700 – 900 series have not been updated for several years. IAN's can be updated at any time. A check should be made on the standardsforhighways web site to ensure the latest documents are used.

0.13 A skidding strategy is published separately.

0.14 It is not permitted, under the public procurement directive (PPD), for any public body to require the use of a particular proprietary product. All such requirements must be specified in performance terms, hence the use of HAPAS certification for proprietary highway materials. Statements such as: 'example product or similar' are also not permitted as they are deemed to steer towards a particular product giving unfair advantage. Additional requirements can be added on a contract by contract basis but they must have technical justification, must be specified in performance terms and must not conflict with published European Standards. In general all coated materials are covered by mandatory CE marking 'in the back of the wagon'. Laying is not covered by CE marking and therefore WCC can specify its requirements without conflicting with the PPD.

0.15 For proprietary bituminous materials the material must conform to one or other of the parts of BS EN 13108. However HAPAS can be used for installation and HAPAS guidelines are in the process of being revised with much more emphasis on the quality of laying and compaction.

Note: the revised HAPAS procedure is currently planned to be published (by BBA) in spring 2016.

0.16 References are given in the form [Catt 1983]; ie authors surname followed by the year of publication. Where the author is unknown the commissioning authority is given instead eg [HA 2002]. The complete list of references can be found in Chapter 21.

0.17 **Users of this document are reminded of their responsibilities under the Construction Design and Management (CDM) regulations to provide designs that are safe to construct, safe to use and safe to maintain.**

Last amendment July 2015

1 Guiding Principles

1.1 The main guiding principles are:

- To have minimum environmental impact
- To have appropriate and balanced levels of safety to minimise casualties
- The minimisation of hazards during installation and maintenance
- To maximise the durability of the pavement structure

Environmental impact

General

1.2 As stated in the introduction the priority order of processes to reduce environmental impact are

1. Reduce material usage over the long term (greater than 40 years)
2. Provide good ride quality
3. Reuse road structure
4. Recycle road materials

Reduce material usage

1.3 In the history of road construction and maintenance two directly opposed philosophies have been used to try and achieve minimum material usage: build a road as thin as possible or build it strong enough to last a long time. Over a lifetime the latter has been demonstrated repeatedly to have the lowest use of raw materials, the lowest maintenance costs and the lowest impact on the travelling public. Some have argued that roads do not last 60 or more years but many of Warwickshire's road have foundations that predate World War 2 and indeed those with Roman origins (eg A5 and B4455) still have remnants of Roman foundations. Therefore this strategy is based on the provision of long life pavements. In order to achieve this durable materials must be used which must be properly installed; it is no good having durable components if inadequate installation means early failure and high maintenance need.

1.4 The long life philosophy does not only apply to the structure of the road but applies equally to such matters as traffic management surfaces and road markings.

1.5 In the context of resurfacing the thinnest surface consistent with other requirements will be chosen.

Ride quality

1.6 Ride quality has a number of effects on the sustainability of the network and the general environment:

- good ride quality maximises the life of the pavement as it minimises impact loading from vehicles
- good ride quality minimises fuel consumption and therefore minimises atmospheric pollution
- good ride quality minimises noise generation (for any given surface type)

Reuse of road structure

1.7 When structural maintenance is being planned the main principle should be making the maximum use of the existing pavement structure. This means that where there are no level constraints the existing structure will be left in place and an appropriate overlay designed and installed using, where it will improve economy, local reconstruction. Reuse, on most of the county's roads, will have a lower environmental cost than recycling as, usually, a relatively thin overlay will increase the life of a road significantly and a recycled road will need a new surface anyway. The other advantage of reuse

is that virtually all roads in the county (as is the case nationally) includes old, hard, tar bound materials. Tar is not a problem if left in situ (this is normally also true when recycled in situ and cold) but can be if removed from site; it certainly is a problem if it is recycled using a hot process. Reuse can be more problematic in urban areas where highway level constraints are much more frequent. To strengthen a road where levels are constrained it is necessary to remove the existing and replace with a thicker or a stronger material. Even in these situations it is sometimes possible to remove a part thickness and replace with a stronger material or remove part thickness and recycle the remainder and resurface.

Recycling

1.8 Recycling consists of breaking up the existing road, treating the broken material using one of a number of processes and relaying it either in the same place or on another section of road. It is always carried out by a specialist contractor and specialised plant is usually required. Advice should be sought from suitable contractors into the feasibility of recycling a particular section of pavement. Because tar is usually present only cold in situ recycling should be considered. This may use either emulsion binder or foamed bitumen. Cement recycling must not be used as it cracks and unless a considerable thickness of bituminous material is placed on top the cracks reflect through to the surface and allow water to penetrate the pavement structure. Many sub-grades in the County are clays which shrink and expand as their moisture content falls or rises so that any structure must be flexible, again leading away from rigid cement based recycling. Emulsion or foamed bitumen recycling sometimes use small amounts of cement – this is not a problem,

Balanced safety levels

Skidding resistance

1.9 This strategy follows the philosophy of the HA (HD28/04 paragraph 1.3). ‘The objective … is to manage the risk of skidding collisions in wet conditions so that the risk is broadly equalised across the network.’ This means that adequate levels of PSV of aggregate combined with aggregate size are provided at each site. Advice on the implementation of HD28/04 is given in CSS Guidance note on skidding resistance dated May 2005. As recent research has shown, PSV is a poor indicator of likely skidding resistance. Further information is given in the relevant chapter. Warwickshire’s strategy for skidding and skidding resistance is published separately, [WCC 2013]

Macro-texture

1.10 At high speed it is necessary to provide either high macro-texture to maintain adequate skidding resistance or, on low texture materials, to increase the measured skidding resistance to compensate for the fall off in skidding resistance with speed. This was shown, indirectly, in old research but recent work has demonstrated this clearly. Advantage is taken of these findings to enable the use of known durable surfacing materials on lightly trafficked roads. Over 95% of the County’s network is classed as lightly trafficked (under 250 cv/l/d). In Scotland no texture requirement is specified in their current SMA specification although skidding resistance is measured [TS 2010].

Casualty reduction

1.11 The minimisation of casualties over the whole network is contributed to by the provision of appropriate skidding resistance at all sites. Unnecessarily high values of PSV should not be used as above a certain value crash frequency is not reduced. This follows from research carried out many years ago by TRL showing that once the skidding resistance level has a certain value (different for each type of site) any further increase does not reduce the frequency of crashes, this research is summarised in [Hosking 1992] and [Catt 1983]. This finding has been confirmed by recent research by the same organisation [Parry and Viner 2005]. In some cases an increase in skid resistance results in increased crash rates.

Installation and maintenance hazards

Manual handling

1.12 Regard is paid to the manual handling regulations. Examples of possible problems are lifting of kerbs and slabs, hand laying bituminous materials and screeding of high friction surfaces and screeded road markings where heavy buckets of hot materials (often over 200°C) are carried and poured.

Vibration avoidance

1.13 Vibration white finger can result from the use of hand held vibrating tools. Due regard is paid to the minimisation of the use of such tools.

Toxic materials

1.14 The main source of toxic materials in road construction materials are pigments. Increasing use of coloured surfaces indicate that much care is needed to ensure that any pigments used are non-toxic. Many pigments are based on heavy metals such as cadmium, chromium and lead; all of which are toxic. There are two major problem areas with their use: as they wear dust is generated which is often fine enough to be included in the 'PM10' count which means it is breathable and therefore has a high level of toxicity. The second is when it is removed from the road. By then the records of what materials were used have often been lost or they are not communicated to the contractor removing the surfaces thus raising the likelihood of spreading toxic materials uncontrollably. Non-toxic pigments are available but are usually less durable and more expensive. Where a coloured surface is required the use of natural coloured aggregates is always preferred as the colour is very durable and aggregate is normally non-toxic.

Services

1.15 As far as possible utility companies should be persuaded to place their equipment outside the construction of the pavement as this reduces hazards during maintenance of the pavement structure. This also eliminates the damage caused to the pavement structure when the services are accessed in the future. It is accepted that placing sewers outside the highway structure is not usually feasible and in such cases they should, as far as possible be placed between the wheel tracks.

Last amendment July 2015

Part 1 New Construction

2 Foundations, drainage and sub-base

Drainage

2.1 This strategy does not deal with the design of drainage systems. They are, however, extremely important and the pavement design strategy assumes that the subgrade is properly drained by a system that keeps the subgrade free of water for the life of the pavement; ie the system shall not only function initially but must either be maintained on a regular basis or be designed not to need maintenance so that it functions at all times. Environment Agency requirements should be followed. There has been significant consideration of drainage recently in connection with major flooding. The most recent guidelines should be followed. Additional guidance on formation and sub-grade drainage can found in chapter 6 of IAN73/06 rev 1.

Proper functioning of drainage of all types is now more important than was traditionally the case as pavements are now designed for long life – in excess of 40 years is usual for new roads. RN42 [TRL 2008] highlights the need for fully functioning drainage throughout the life of the pavement

Note: If the drainage fails the life of a pavement can be more than halved and indeed nearly 100% of all failures of a road structure include water as the main or a significant contributor cause.

2.2 It is also important that storm water drainage is properly designed, constructed and maintained as poor disposal of surface water will increase the amount of water entering the structure and this will reduce the life of the road. It is recommended that, as far possible, gullies and other devices to collect run-off should be kept out of the main carriageway as they seriously weaken the structure. Evidence is beginning to be gathered showing that irregularities in the running surface (particularly those affecting one wheel track such as those formed by depressed gullies) can be a cause of crashes.

When the lane width is less than 3.5 m it is inevitable that heavy vehicle wheels on the nearside will overrun the gullies or their supporting structure; these are, by far, the weakest area of a road structure. The results can be seen along many roads within the County where the gully structures have been depressed. The irregularities are such that cyclists will ride further into the road than is ideal and the poor ride quality induces further high load impacts downstream of the gully. Where gullies or equivalent drainage designs are off line maintenance is hugely simplified both for surface dressing or paver laid inlays or overlays.

Where kerb drainage systems are used, for example Beany blocks, they should not be used in locations where over-riding by truck wheels could occur as they are not designed for the horizontal shear loading that inevitable occurs when the wheel mounts the kerb. Drainage on the high points of a pavement is both an unnecessary cost and could lead to drainage blocking as there is no flow to keep the system flushed out.

Sub-base

2.3 The foundation specification for trunk roads was totally revised in IAN 73 and is no longer considered to be merely a construction platform for the structural layers. The specifications for both capping and sub-base should logically be in the 800 series and it has been confirmed with the Highways Agency that this is the intention when resources allow. It is therefore appropriate that in this strategy the traditional description of sub-bases, Wxx is used rather than variations on the 600 series description of 6Fxx for the lower layer. The strength of capping has been downgraded when compared to earlier designs of foundation layers. Also the total thickness of foundation has generally been increased. Warwickshire has a long history (half a century) of using permeable sub-bases and capping layers.

2.4 Permeable sub-bases have significant advantages when it is proposed to use recycled materials:

- They are stable in all moisture conditions including full saturation (the normal state on clay subgrades after a number of years when no drainage maintenance is carried out)
- No frost heave testing is needed for either the open graded material or for the thin layer of regulating material used on top as there is no capillary path for water to migrate to form ice-

lenses. This is a great advantage when using recycled type 1 for regulating as otherwise a frost test (very expensive) would be needed for each source which might consist of relatively small quantities.

- They do not require much compaction which minimises breakdown of materials that may be relatively soft.
- The actual grading is not critical provided the fines content is very low and the materials are very permeable. The maximum size should be compatible with the size of the equipment used to place the material.
- Warwickshire sub-bases have traditionally been thinner than the foundations for Highways Agency (because they are stronger than 6F1 and 6F2 capping materials and are much less sensitive to waterlogging).

2.5 The specification for Warwickshire sub-bases, W150 and W75 is given in part 3. It has been written in terms of minimum permeability with a 'deemed to comply' grading limit, which limits the amount of fines in the product. This enables easy use of recycled materials particularly those of WCC's own production. Within the overall thickness the maximum thickness of the 'W' materials shall be used with a minimum thickness of type 1 or type 3 from SHW which is used as a regulating layer to give an even surface to the sub-base on which to lay the bituminous base layer. Type 2 may be used but only those containing at least 80% of bituminous planings. W75 is normally used only where space is limited such as in strip widening and where significant proportion of the material has to be manhandled. W150 is preferred where machine placing is used such as half lane widths or more.

2.6 Designs for use with 6F2 (the finer 6F1 is not acceptable) are given in table A2.1. Use is to be avoided if at all possible s the materials are far less tolerant of water-logging then WCC sub-bases and need far more attention to drainage over the long term (life of road). The design is also thicker and hence needs more earthworks.

2.7 Figure 1 shows the design process for sub-base thickness. The process used depends on whether or not a site investigation has been carried out. On small schemes the saving in the amount of sub-base is unlikely to cover the cost of carrying out even a simple site investigation together with a sufficient number of plasticity indices and the necessary testing of CBRs on site. It is thought that the size of scheme for breakeven is likely to be around 1000 sq m or more depending on saving of sub-base thickness and obviously its cost and the cost of disposing of arisings.

2.8 The sub-base is classified as a class 2 foundation in HD26/05. Table 2.1 gives the relevant thicknesses using default values of CBR. Table 2.2 gives the CBR for common sub-grade materials, which should be used in the design in most cases.

2.9 The substitution of Types 1, 2 or 3 sub-base (in SHW these are called 'unbound mixtures) for W150 or W75 must not be permitted as none of them are sufficiently permeable. Table 2.2 is extracted from HD25/94 to cover the soil types found in Warwickshire and simplifies it to summer or winter construction. If the CBR measured at the time of construction is lower than that given in the table then the lower figure shall be used for design. A measured CBR higher than that indicated by the table must be ignored. All the caveats and warnings in IAN73 regarding CBRs must be noted and considered.

2.10 The sub-base should be laid in layers with a thickness not exceeding 4 times the nominal size of the material (this is called 'D' in European Standards)

Note 1: bituminous planings are now included in type 2 unbound mixtures

Note 2: for the background on W150 and W75 see supporting papers (held by Network Management)

2.11 Type 1 unbound mixture shall be placed at a moisture content between optimum and optimum-2% measured using the vibrating hammer test in BS 5835 part 1 :1980.

Note: this is considerably wetter than is usually the case

Figure 1 Design Process for Sub-Base Thickness

<table>
<tr><th colspan="4">Site investigation carried out?</th></tr>
<tr><th>No</th><th></th><th colspan="2">Yes</th></tr>
<tr><td>Use thickness given in Table 2.1 for the obvious soil types (default values)</td><td></td><td colspan="2">Use thickness given in table 2.3 on the basis of CBRs determined from table 2.2 using soil parameters determined as a result of a site investigation</td></tr>
<tr><td></td><td></td><td colspan="2">Measure CBR immediately prior to placing sub-base</td></tr>
<tr><td></td><td></td><td colspan="2">Is CBR at or above design CBR?</td></tr>
<tr><td></td><td></td><td>Yes</td><td>No</td></tr>
<tr><td>Construct sub-base at the default thickness.*</td><td></td><td>Use design thickness</td><td>Increase thickness to that required for the measured CBR</td></tr>
</table>

*it is good practice to measure the CBR at this stage to check that it is not below the low limit of CBR for the thickness. If it is then use additional thickness.

NEVER, NEVER reduce the sub-base thickness below the design thickness as a result of measuring the CBR. The design thickness is determined using the long term stable CBR which is frequently lower than the CBR at the time of construction particularly when construction takes place in summer..

Table 2.1 Default sub-base Thicknesses

CBR	Total sub-base thickness (nominal)	W sub-base	Type 1 or 3 Sub-base or bituminous road planings (type 2)
%	mm	mm (minimum)	mm (maximum)
<2 (Lias clay)	750	600	150
2-5 (Keuper Marl)	500	350	150
5-15 (non-plastic sands)	300	150	150
>15 (non-plastic gravels)	200	0	200

See paragraph 2.5 for method of choosing between W75 and W150.

The thickness of the ‘W’ sub-bases should be maximised within each category with types 1 - 3 reduced to the role of a regulating layer.

Table 2.2 Design CBR

Soil type	PI	Construction period	
	%	Winter	Summer
Heavy Clay (typically Lias)	70	1.5	2
	60	1.5	2
	50	1.5	2
(typically Mercia mudstone (marl))	40	2	2.5
Silty Clay	30	2.5	3
Sandy Clay	20	2.5	4
	10	1.5	3
Silt		1	1
Non-plastic Sands		10	20
Sandy Gravels		20	40

PI is plasticity index - see BS 1377:1990

Table 2.3 Design Sub-base Thicknesses (for 'large' contracts)

CBR	Total sub-base thickness (nominal)	W sub-base	Type 1 or 3 Sub-base or bituminous road planings (type 2)
%	mm	mm (minimum)	mm (maximum)
<2	750	600	150
2	500	350	150
2.5	450	300	150
3	410	260	150
4	360	210	150
5	320	170	150
6-8	300	150	150
8-10	250	100	150
10-15	225	0	225

A large contract is one where there is a laboratory on site capable of carrying out the large amount of testing required.

Table 2.4 Default sub-base Thicknesses for 6F2 capping

CBR	Total foundation thickness (nominal)	6F2 capping (note 2)	Type 1 or 3 Sub-base or bituminous road planings (type 2)
%	mm	mm (minimum)	mm (maximum)
<2 (Lias clay) (note 1)	930	280 + 250 W75	400
2-5 (Keuper Marl)	680	280	400
5-15 (non-plastic sands)	450	210	240
>15 (non-plastic gravels)	300	150	150

The use of this design is deprecated in Warwickshire.

Note 1: Where Lias clay is encountered the extra 250 mm of capping should be W75 or equivalent drainage layer below the 6F2

Note 2: A non-woven geotextile must always be placed below the 6F2 to prevent contamination of the material by clay. This is because the 6F2 in unlikely to be free draining and will over time become saturated even with fully working drainage. The geotextile should be non-woven and with a minimum mass of 200 g/m^2 (an example would be Terram 2000). The grade is set by the maximum aggregate size of the layers being separated.

Appendix A to Chapter 2

Class 2 foundation design using 6F2

Designs for use with 6F2 (the finer 6F1 is not acceptable) are given in table 2.4. It should be noted that the construction thickness on virtually all of Warwickshire's soils will be significantly thicker than is using the open graded W materials. There is also the additional requirement for a geotextile separation layer between the soil and the capping to avoid cross-contamination and also the need to complete the subgrade drainage before installing the capping. See IAN 73/06 rev 1 chapter 6 and in particular paragraph 6.2. The design is based on IAN73 rev 1 table 3.2 which gives a class 2 foundation. A wholly capping design is given in table 3.1of IAN73 but it only provides a class 1 foundation and would require an additional 40 mm of bituminous base.

Table 2.4 Default sub-base Thicknesses for 6F2 capping

CBR	Total foundation thickness (nominal)	6F2 capping (note 2)	Type 1 or 3 Sub-base or bituminous road planings (type 2)
%	mm	mm (minimum)	mm (maximum)
<2 (Lias clay) (note 1)	930	280 + 250 W75	400
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5-15 (non-plastic sands)	450	210	240
>15 (non-plastic gravels)	300	150	150

The use of this design is deprecated in Warwickshire.

Note 1: Where Lias clay is encountered the extra 250 mm of capping should be W75 or equivalent drainage layer below the 6F2

Note 2: A non-woven geotextile must always be placed below the 6F2 to prevent contamination of the material by clay. For the low CBR (Lias clay) design the geo-textile should be placed between the drainage layer and the 6F2 to prevent the fines from the 6F2 contaminating and clogging the voids of the drainage layer. This is because the 6F2 in unlikely to be free draining and will over time become saturated even with fully working drainage. The geotextile should be non-woven and with a minimum mass of 200 g/m^2 (an example would be Terram 2000). The grade is set by the maximum aggregate size of the layers being separated.

3 Structural layers for new roads (except adoptable roads)

3.1 The structural layers of all new roads shall be asphalt concrete using 100/150 grade bitumen. The layer thickness shall be as shown in table 3.1. The assumed design life is 40 years. This section does not include the design of adoptable roads, see section 7 for the design for these roads.

Table 3.1 Construction thickness for new roads

Traffic level	Base thickness mm	Binder course thickness mm
Up to 1 msa (this includes all HAUC type 4 roads, and all roads carrying up to 100 cv/l/d). All of these will have 55/10F surfacing.	100*	60
1 to 5 msa (this includes all HAUC type 3 roads, and all roads carrying up to 500 cv/l/d) with 55/10F or 10 mm SMA surfacing	150*	60
Above 5 msa (ie HAUC type 0, 1 or 2 roads and roads carrying more than 500 cv/l/d). A traffic count is required. (Or for new roads an estimate)	As figure 2.2 of HD 26 less thickness of structural surfacing	

* The base thicknesses assume 40 mm of low void surfacing. Where a different thickness of structural surfacing is used these thicknesses should be adjusted to maintain overall structural thickness.

NOTE 1: The levels of traffic for the HAUC categories have been doubled compared to those given in the specification for reinstatements in Highways as the design life is 40 years and not 20 assumed by HAUC.

NOTE 2: The HAUC classification can be obtained from the Street Works Register team

3.2 The base shall be AC 32 dense base 100/150 recipe mixture to BS EN 13108-1 and PD 6691. Where a new road is being built that does not have any underlying utilities, **and** will not have any in its lifetime, 40/60 binder may be used in place of 100/150 binder with the design thickness in accordance with Figure 2.2 of HD 26. Design mixtures may be used but only with express written permission of Warwickshire County Council after the provision of all relevant information. The use of gravel aggregate is not permitted. EME2 is not suitable for use on WCC roads as its design costs are high and it would only be useable where 40/60 pen binder is useable and the saving in thickness would be marginal with WCC traffic levels.

3.3 The binder course shall be AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 and PD 6691. Where a base with 40/60 binder is used then the binder course shall likewise use 40/60 binder. Design mixtures may be used but only with express written permission of Warwickshire County Council after the provision of all relevant information. The use of gravel aggregate is not permitted.

3.4 A bond coat in accordance with clause 920 of the Specification for Highway Works shall be used between all structural layers. Clause 920 requires that all bond coats are applied using a spray bar. More information is given in BS 594987 clause 5.5. The bond coat should not be sprayed more than 24 hours before the next layer is placed on class D roads or not until the lane has been closed to traffic for roads of higher classification. The rate of spread shall be such that the bond requirement of clause 975AR are met. The rate of spread required is likely to be higher than that given in BS 594987 if the road is at all porous or dirty.

NOTE: A bond coat is a polymer modified emulsion although there are likely to be developments in binder technology which will permit modified hot binders without flux to be used (A tack coat is an unmodified emulsion such C40B2 or C69B2; these are no longer permitted.)

3.5 Cementitious materials shall not be used for structural layers on any grade of road.

NOTE: all cementitious materials crack. To prevent the cracks propagating to the surface it is necessary to overlay the cement bound layer with a minimum of 175 mm of bituminous material. On major trunk roads this would be within the design thickness but for all County roads it uses extra high cost materials compared to an all bituminous design.

3.6 The level of compaction shall be measured by means of void content. The void content shall not exceed 6% for either the base layers or the binder course for the mean of each set of 6 cores; regardless of whether the Asphalt Concrete is recipe or design. The compaction close to a joint as defined in clause 903 shall be such that the air voids shall be not more than 2% above that specified

for the main mat. The specification, based on clause 929 of the SHW is in the WCC standard document as 973AR which is reproduced in Part 3.

3.7 Resistance to deformation for the binder course should not be specified for roads carrying less than 500 cv/l/d. For roads carrying more than this the deformation resistance shall be class 1 when tested in accordance with BS 594987. No requirements for the deformation resistance of the base should be specified on any county road.

Last amendment July 2015

4 Surfacing new roads and bridge-decks

4.1 Surfacing shall be one of two types. A summary of the type to be used, and where, is given in table 4.1. This table uses commercial vehicles per lane per day (cv/l/d) as defined in HD 24 and the speed limit as the parameters affecting the material choice. All bituminous materials delivered to site shall have a CE mark.

Table 4.1 Summary of preferred surfacing for new work

<table>
<tr><th>Speed limit (mph)</th><th>Traffic 100 cv/l/d and below</th><th>Traffic above 100 cv/l/d</th></tr>
<tr><td>20</td><td rowspan="6">Hot Rolled Asphalt 55/10F surf 100/150 (see para 4.2)</td><td rowspan="3">Hot Rolled Asphalt 55/10F surf 100/150 (see para 4.3)</td></tr>
<tr><td>30 and roundabouts and traffic lights on roads with higher limits</td></tr>
<tr><td>40</td></tr>
<tr><td>50</td><td rowspan="3">SMA 10 (surf) to BS EN 13108-5 (see para 4.4)</td></tr>
<tr><td>60</td></tr>
<tr><td>70</td></tr>
</table>

Note: where a new section is being inserted into an older road (eg a right turn lane) it is usually appropriate to match the surfacing type with the existing except where the existing is surface dressing.

4.2 On all roads carrying less than 100 cv/l/d the surfacing material shall be Hot Rolled Asphalt HRA 55/10F surf 100/150 to BS EN 13108-4 as described in PD 6691.

NOTE: this has traditionally been called medium temperature asphalt (MTA) in Warwickshire

4.3 On roads carrying more than 100 cv/l/d with a speed limit of 40 mph or less the surfacing material shall be Hot Rolled Asphalt HRA 55/10F surf 100/150 to BS EN 13108-4 as described in PD 6691. This surfacing shall also be the first choice for new roundabouts and traffic light junctions on roads with higher speed limits; however, if these are part of a larger scheme then the surfacing chosen for the whole scheme may be carried through. SMA surfacing on the circulation area of small roundabouts should be used with great caution and the supplier specifically asked to demonstrate its suitability in such locations.

4.4 On roads carrying more than 100 cv/l/d with a speed limit above 40 mph the first choice surfacing material would be SMA 10 (surf) to BS EN 13108-5 and PD 6691 Further advice on selecting and using these materials can be found in 'Best practice guidelines for specification of modern negative texture surfaces (NTS) on local authority roads' [DfT/UK Roads Board 2006]. Specifications for SMA surface course are given in Part 3 – 976AR. HAPAS surface courses may be used but only those that comply with the compaction requirements of clause 973AR shall be used. A choice of binders is given in clause 976AR. For normal use either 65/105-45 or 75/130-45 may be used. Some binder suppliers supply one of these and some the other. The other binder, 75/105-75, is a high performance binder (hence more expensive) and its use will be limited to sites where its resistance to crack transmission is needed.

4.5 As an alternative to either of the above the use of hot rolled asphalt and chippings may be used. The specification to be used shall be: HRA 30/14F 40/60 (or 100/150) recipe Schedule 1A as specified in BS PD 6691 Annex C. The chippings shall conform to BS PD 6691 table C5 20 mm nominal size and shall be spread at a rate of 70% shoulder to shoulder. Texture depth must not be specified. The normal binder would be 40/60 pen but for lighter trafficked roads where rutting is unlikely to be a problem 100/150pen may be used with particular advantage in cooler conditions. The use of the trunk road standard of 35/14F des as used on trunk roads should not be used as it needs heavy traffic for best durability.

4.6 The polished stone value shall be specified in accordance with the table in Annex B. Higher values should not be specified unless a written justification is lodged with Head of Highways and

Transport prior to issuing a contract. The values in Annex B include a sufficient safety margin and using higher values will not further reduce skidding crashes except in exceptional circumstances.

NOTE 1: the Head of Highways and Transport has approved this document as a whole including the PSV values herein.

NOTE 2: if skidding crashes still occur with high values of skidding resistance the layout of the road is probably at fault.

NOTE 3: recent research has shown that very high skid resistance values can be associated with increased crash frequency.

4.7 The resistance to surface abrasion shall be AAV_{10}.

4.8 The level of compaction for the hot rolled asphalt, SMA and HAPAS surfaces shall be in accordance with the requirements given in clause 973AR in Part 3. Durability, stiffness, and deformation resistance are all closely related to compaction level and inadequate levels of compaction will result in reduced life.

NOTE 1: A paper published recently explains why void levels above about 4% increase the risk of material having a reduced life; Pothole formation: experiments and theory. [Thom 2005]

NOTE 2: research in Germany, quoted by ADEPT (July 2014) found that SMA with 5 % voids lasted 25 years and with 8% voids only 8 years.

4.9 All the usual requirements for surfacing performance such as compliance with straightedge requirements (SHW 701), texture depth and finished level must be achieved for all surfacing. There is no requirement for texture depth when 55/10F HRA or SMA to BS EN 13108-5 is used but this is allowed for by using higher PSVs for these materials compared to others, see Annex B for details.

4.10 Regardless of the type of new surfacing, ironwork within the carriageway shall be reset to its final level before the surface course is laid. If for some very good reason this not done then the area around the ironwork which is cut out in order to reset it shall be reinstated with a HAPAS certificated inlaid crack sealing system (eg Permatrack). On no account shall the hand laying of thin surfacings be attempted as they always fail very early.

NOTE: 'Permatrack' is given here as an example for information. It cannot be specified as such as that would contravene the Public Procurement Directive (PPD)

4.11 **Bridge-deck surfacing** should follow the general requirements of IAN96/07rev 1 with the following exceptions:

- Waterproofing membranes needing an asphalt protection must not be used
- All materials used in subsequent layers shall have a target void content of 4 % and shall comply with clause 973 AR.
- The system shall be used for all thicknesses of bituminous materials
- The surface course should match the surface course used on either side of the bridge

Last amendment July 2015

5 New footways and cycleways

Footways

5.1 The footway design should accord with HD 39 for the traffic level chosen. Light vehicle design will be the most common. Untrafficked design shall not be used when sweepers or other maintenance vehicles are used that are not pedestrian controlled. Footways combined with cycleways shall have the same construction as the cycleway.

NOTE: There should be no step between the cycleway and footway when they use the same route and are immediately adjacent to each other. Separation should be by means of a white line only. A longitudinal step of less than 25 mm can 'throw' a cyclist if it is crossed at a narrow angle, for example, to avoid pedestrians.

5.2 HD 39 gives a two course surfacing design. As an alternative 50 mm of asphalt may be used in a single layer; the asphalt shall be 55% stone content when machine laid or 45% stone content when hand laid. Machine laying of all bituminous surfacing materials on footways is the default option. Permission shall be sought from the Warwickshire County Council to lay the surfacing by hand.

NOTE: the specification for 45% hot rolled asphalt, both 45/10F and 45/6F, are given in 970AR (in Part 3).

Cycleways

5.3 Cycleways included as part of the carriageway shall have the same construction as the carriageway.

NOTE: for safety reasons cycleways as part of the carriageway should be avoided in new works.

5.4 Cycleways are normally maintained using ride on vehicles and therefore they shall always be constructed using the light vehicle design, or any of the heavier options. The preferred option shall be bituminous construction as the ride quality is always better than segmental paving. Concrete shall never be used. The bituminous material shall always be machine laid as the ride quality of hand laid material is usually very poor and is never comfortable.

5.5 Although HD 39 is for footways the construction for light vehicles is suitable for cycleway use. It gives a two course surfacing design. As an alternative 50 mm of asphalt may be used in a single layer; the asphalt shall be Hot Rolled Asphalt 55/10F surf 100/150. Hand laid 45/10F is not an option for cycleways the ride quality is not good enough.

5.6 On high plasticity clay subgrades – typically Lias – shrinkage cracking frequently occurs. There is no known prevention for this without extremely high construction thicknesses (750 mm or more) which are obviously uneconomic. It might be useful to carry out a trial incorporating a glass fibre grid (eg Geogrid) within the construction, either at the bottom of the sub-base, within the sub-base or at the base of the bituminous layers.

5.7 When a cycleway crosses a kerb line the kerb must be flush otherwise cyclists will swing out into the road to cross the step at near right angles.

Last amendment July 2015

6 Cycle paths and trails

6.1 These are routes for cyclists that are constructed of unbound aggregate. Standards are being developed nationally for these and the county cycling officer shall be consulted to determine the latest position if paths or trails are constructed by the County Council. Sustrans have an extensive library of design manuals and codes. In particular TIM 8 chapter 6 (technical information manual)

Last amendment July 2015

7 Adoptable roads

7.1 The majority of these are for residential development. In previous editions of this document the various types of road eg type 4 collector roads were described in the estate road design guide and the structural design was given for each. The current planning guidance has done away with these classifications and this document follows the current planning guidance in giving different designs depending on the width of carriageway and the use to which the road is put. All designs are, as recommended by the CSS in ENG6/94 [1994], for a structural life of 60 years; maintenance of the surfacing being carried out as required during that lifetime. Achieving this structural life requires the provision of adequate thickness of structure and good workmanship when constructing the road, in particular proper compaction. The intention behind this long life requirement is that existing council tax payers should be in no worse position than they would have been had the development not taken place. As part of this it is essential that the design, execution and workmanship are checked and tested before committing the County to adopting the road or footway for maintenance.

7.2 The construction thicknesses given below relate to the 'optimum' widths given in the 'Transport and Roads for Developments: The Warwickshire Guide 2001' (this is available from development control and is not on the Warwickshire web site as most of it has been superseded). Roads for the same class built narrower than optimum shall be constructed to the same thickness as it can be expected that the traffic carried will not be less. In summary the carriageway widths are as follows:

- 7.3 m – this is for large industrial developments and other roads carrying significant numbers of heavy vehicles
- 6.7 m – small scale industrial developments, business parks, most bus routes in residential streets
- 6.1 m – business parks and bus routes in residential streets; in either case where no demand for on street car parking is anticipated.
- 5.5 m – residential roads serving more than 50 dwellings
- 5.0 m – residential roads serving up to 50 dwellings and where the traffic speed is expected to exceed 10 mph
- 4.5 m – residential roads serving less than 12 dwellings, traffic does not exceed 10 mph and pedestrians and those with impaired mobility have absolute priority.

Service trenches

7.3 It is essential that the backfilling of service trenches is fully compacted and placed in layers of a thickness appropriate to the capability of the compaction plant being use. Alternatively W75 may be used without compaction.

Sub-base

7.4 The construction thicknesses for these are as given in chapter 2. The thicknesses relate purely to the bearing capability of the soil and are independent of the traffic level.

Pavement construction

7.5 Construction requirements shall be as for new roads given in chapters 3 and 4 of this strategy but with increased thickness to allow for the longer design life. From the maintenance viewpoint the bituminous options given in tables 7.1 – 7.3 are preferred. Any other construction and surfacing (including coloured) shall be assessed for maintenance liability and in the probable event of it being higher an appropriate commuted sum will be charged; experience has shown that in virtually all cases the bituminous option gives the lowest long term maintenance costs. Bituminous surfacing shall be 55/10F surf with 100/150 pen binder. SMA is not used as the speed limit is usually 30 mph or less.

NOTE: as an example segmental paving always costs more to maintain – not because the segments are less durable (they are not) but they often need relaying, which is expensive, often at intervals of less than 10 years.

7.6 Safety is paramount. In addition to the speed reduction measures dealt with in 'Transport and Roads for Development' it is a requirement that the road surface presents a safe interface to all users. As a minimum the Polished Stone Values given in Appendix C must be adhered to; care should be taken to ensure that all the higher values needed because of sharp bends and junctions are considered.

7.7 *7.3 m and wider single carriageways*

Table 7.1

Layer	Thickness	Material
Surface Course	40 mm	Hot Rolled Asphalt 55/10F surf 100/150 to BS EN 13108-4 (PD 6691) with a PSV_{60} and AAV_{10} aggregate
Binder course	60 mm	AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691).
Base	200 mm	AC 32 dense base 100/150 recipe mixture to BS EN 13108-1 (PD 6691)

Where the traffic density is such that a dual carriageway is required then the construction shall be determined in consultation with the County Council but is likely to be thicker, in total, than that given above.

7.8 *6.7 m and 6.1 m wide roads*

Table 7.2

Layer	Thickness	Material
Surface Course	40 mm	Hot Rolled Asphalt 55/10F surf 100/150 to BS EN 13108-4 (PD 6691) with a PSV_{60} and AAV_{10} aggregate
Binder course	60 mm	AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691).
Base	150 mm*	AC 32 dense base 100/150 recipe mixture to BS EN 13108-1 (PD 6691)

* If the developer wishes to lay the base in two layers then AC 20 dense bin 100/150 may be used in place of the AC 32 dense base 100/150

7.9 *5.5 m wide and narrower roads and areas with shared use*

Table 7.3

Layer	Thickness	Material
Surface Course	40 mm	Hot Rolled Asphalt 55/10F surf 100/150 to BS EN 13108-4 (PD 6691) with a PSV_{60} and AAV_{10} aggregate
Binder course	60 mm	AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691).
Base	125 mm*	AC 32 dense base 100/150 recipe mixture to BS EN 13108-1 (PD 6691)

* If the developer wishes to lay the base in two layers then AC 20 dense bin 100/150 may be used in place of the AC 32 dense base 100/150.

7.10 Segmental paving may be permitted for these roads with the following provisos: only rectangular pavers 200 mm x 100 mm and 80 mm thick in accordance with BS EN 1338 or BS EN 1344 are permitted. The paving shall be carried out in accordance with BS 7533. Special shaped blocks may not be used as they are impossible to re-lay satisfactorily after they have been removed to gain access to underlying services. Pavers shall be laid in a 45º herringbone pattern as shown in the ADEPT guidance on surfacing. Great care must be taken that the bedding material (sand) is well and permanently drained as any water logging of the sand with ensure rapid failure as the sand can no longer support the traffic loads. The minimum requirement for draining the sand is to drill 25 mm holes through the asphalt layers at 300 mm centres in each direction. These core holes shall be filled

with 2.36/6 mm single size chippings prior to spreading the bedding sand. Other drainage systems may be employed but they must be demonstrated as having at least equivalent performance for the life of the pavement. An alternative is to lay them rigidly but this is not always straightforward and consideration should be given to the risk of failure and the necessary high cost of either relaying or replacing with a bituminous surface.

NOTE: although blocks normally have a long life as a block the surface in which they are used often does not unless the workmanship is of very high quality; this means they can be relaid but at high cost. However carefully this is done there is always some loss of block especially as cut blocks. It is probable that where pavers other than those defined above are used a high commuted sum would be required.

7.11 There is a serious safety problem using pavers to BS EN 1338 or BS EN 1344. There is no equivalent to the polished paver value (PPV) test (included in BS 6677 and BS 6717 which are now obsolete) which ensured that adequate skidding resistance was maintained during the life of the pavers. If a developer wants to use block paving on these roads then he must provide evidence in the form of a PPV test result for the paver in question before he is permitted to do so. The pavers shall have a minimum polished paver value (PPV) of 55. As an alternative, for concrete pavers only, all the constituents shall be from quarries having an aggregate with a polished stone value (PSV) of at least 55.

NOTE 1: there have been occasions in the past when a PPV has not been specified and a high level of skidding crashes have ensued after a couple of years wear even where the initial skidding resistance was adequate.

NOTE 2: the advice given in HD 39 (DMRB volume 7), which is accepted as best practice, is that only standard rectangular pavers should be used. Although the durability of elements is not a problem, areas constructed with them often have fairly short lives. Using other than standard blocks may commit the Authority to a higher than expected maintenance charge in the future if, in order to repair a failure, all the blocks in an area need to be replaced. The likelihood is that if the paving fails it will be taken out and replaced with bituminous materials.

NOTE 3: no local authority can require the use of any particular brand of paver as to do so would contravene the requirements of the public procurement directive, however it is permissible to require additional performance characteristics where they can be justified..

7.12 The construction shall be as shown in Table 7.4

Table 7.4

Layer	Thickness	Material
Surface Course	110 mm	80 mm thick pavers on 30 mm sand bed
Base/binder course	160 mm	AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691) laid in two layers. Perforated as described in para 7.10.

This construction permits site traffic to use the top of the base/binder course layer during construction of the housing. The base binder course must be perforated prior to laying the block paving. The perforations shall consist of 25 mm diameter core holes through the whole of the asphalt layers. These core holes will be backfilled with 2.36/6 mm chippings prior to spreading the sand. They must not be backfilled with the bedding sand.

Footways and cycleways

7.13 Footways shall be constructed in accordance with table 7.5 which consists of appropriate extracts from HD 39 amended to use more durable materials. The construction for residential areas assumes light vehicle use and occasional overrun by goods vehicles and is therefore suitable for drive accesses. The construction for non-residential roads assumes occasional overrun by HGVs. Where higher traffic levels are anticipated, eg crossings into large distribution warehouses, then a full highway pavement design appropriate to the anticipated traffic will be needed. Sub-bases shall be type 1, type 3 or planings with above 80% asphalt content. Particular care should be given to evenness of the final surface for both footways and cycleways as many vehicles, for example child's buggies, wheel chairs and bicycles that use these surfaces do not have suspension. Machine laying is preferred for the binder course as overall quality is usually better and it also minimises thickness variations in the surfacing. Where vehicles cross the footway or cycleway the blocks shall be laid in a 45º herringbone pattern as recommended in ADEPT guidance.

7.14 For safety reasons only pavers which have been demonstrated to have adequate long term skidding resistance either by means of a PPV test or by using aggregate with a PSV in excess of 50 (concrete pavers only) shall be used.

Table 7.5 footway and cycleway construction

Footways and cycleways in residential areas			
Surface course	40 mm thick Hot Rolled Asphalt 55/10F surf 100/150 to BS EN 13108-4 (PD 6691)[1] with a PSV_{50} and AAV_{10} aggregate	65 mm thick pavers[3] or 400 mm x 400 mm slabs or mix all with a PPV of 50 minimum on a well drained 30 mm sand bed	
Binder course	60 mm AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691)	60 mm AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691)	
Sub-base			
CBR of subgrade	≤ 2%	2-5%	> 5% (rare in Warwickshire)
Sub-base thickness[2]	250 mm	200 mm	150 mm
Footways and cycleways in industrial and other non-residential areas			
Surface course	40 mm thick Hot Rolled Asphalt 55/10F surf 100/150 to BS EN 13108-4 (PD 6691) [1] with a PSV_{50} and AAV_{10} aggregate	80 mm thick concrete pavers[3] with a PPV of 50 minimum on a well drained 30 mm sand bed	
Binder course	100 mm AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691)	100 mm AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691)	
Sub-base			
CBR of subgrade	≤ 2%	2-5%	> 5% (rare in Warwickshire)
Sub-base thickness[2]	365 mm	250 mm	200 mm

Note 1: 55% is the normal stone content but where it impossible to machine lay the material 45% stone material may be used in limited areas (the specification can be found Part 3)

Note 2: where the sub-grade is frost susceptible the sub-base thickness shall be increased to bring the total construction thickness to 450 mm. Where the sub-base thickness is above 200 mm a combination of W75 with type 1 or type 3 may be used. (Road planings to type 2 and containing at least 80% bituminous materials may used in lieu of types 1 or 3)

Note 3: the same constraints on shape shall apply as for pavers used on roads

Note 4: 25 mm of 55/6F may be used as a surfacing instead of 40 mm of 55/10F provided the binder course thickness is increased by 15 mm to maintain the structural life.

Part 2 Maintenance

8 Maintenance design process

Information gathering and assessment

Introduction and background

8.1 A wide range of information is needed, from various sources, to enable the optimum amount and type of maintenance to be carried out. If too little is done then the highway network will deteriorate, both structurally and in safety, with increasing rapidity. If too much, or the wrong sort, then resources, both financial and material, will be wasted.

8.2 The standard process of management is changing from a simple, needs based, approach to a much longer term asset management approach. At the simplest level Warwickshire has the following lengths of the various classes of highway (July 2003 figures):

- A roads 433 km
- B roads 430 km
- C roads 862 km
- D roads 2004 km
- E roads 107 km
- F footways off line of highways 138 km

8.3 The current asset value of the network as measured by Gross replacement cost in accordance with whole government accounts finance rules is £7.66 billion of which just over £4 billion is attributable to carriageways and footways; ie excluding land, structures, lighting and signs and signals.

8.4 In addition to the human suffering caused, road casualties represent a financial cost to the community. Potential savings from casualty reduction should be taken into account in the maintenance design process. 'Road Casualties Great Britain' published by DfT assesses the financial benefit of preventing the different severities of casualties and are shown in table 8.1 (2012 values).

Table 8.1 savings from prevention of crashes

Casualty type	Potential saving per casualty (2012 prices)	Potential saving per crash (2012 prices)
Fatal	£1,703,802	£1,917,766
Serious	£191,462	£219,043
Slight	£ 14,760	£23,336

In addition the value of damage only crashes cost an estimated £1935 in built up areas (speed limit 40mph or less) and £2720 on other roads (2012 prices). In addition there are delay costs to other motorists and these are likely to rise as traffic levels increase and the Police treat more crashes as ‘scenes of crime’ which means a road is closed for a longer period of time.

The total cost of the 2,999 road casualties in Warwickshire in 2004 was £161 million. In 2007 the total number of casualties on Warwickshire roads reduced to 2677 at a cost of £141 million. In 2013 the total number of casualties was 1944 of which 23 were fatal, 265 were serious and 1656 were slight. The cost in 2013 of these casualties was £114 million.

The main source of data on road casualties is the database maintained by the Road Safety Intelligence Team in Traffic and Road Safety.

8.5 The main advantage of asset management is that the cost of maintenance is calculated on a whole life basis and the maintenance option which maximises the asset value with the lowest total expenditure over the life of the pavement can be determined. Even if it were not possible to carry out

all the optimised maintenance the penalties for not so doing can be calculated. Also calculable would be whether the total asset value were increasing or decreasing.

Data sources

8.6 The main sources of data used to assess maintenance needs are:

- SCANNER
- Coarse visual inspections (CVI)
- SCRIM
- Deflectograph (unfortunately only old data is now available)
- Serviceability inspections
- Collision data
- Information from the public

8.7 The main sources of data used to design maintenance treatments are:

- Deflectograph (unfortunately only old data is now available but is still useful)
- Collision data
- Road Note 39 (for surface dressing)
- Traffic flows
- Records of historic maintenance treatments
- Various parts of Design Manual for Roads and Bridges (DMRB) volume 7
- SCRIM
- This document

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9 Maintenance options

General

9.1 Maintenance covers a wide range of possibilities ranging from a minimum intervention of 'patch and make do' to a significant structural overlay, or, on rare occasions, total reconstruction. Different treatments have different properties and the choice will depend on the required final outcome. Availability of finance should not be part of the initial decision making process. If insufficient funds are available and a lower level of maintenance is carried out than is justified technically then the fact should be recorded and the site monitored to determine, for future use, the cost effectiveness of the reduced maintenance. A summary of the options is given in table 9.1 together with a summary of their properties. More information is given in HD31 for flexible roads and HD 32 for rigid ones.

9.2 Each option should be considered on a cost benefit analysis. An assessment should be made of the street scene amenity value so that it can be included in the analysis.

9.3 The optimum treatment will depend on what the need is. For example if the need is simply to restore skidding resistance then surface dressing is likely to have the highest benefit to cost ratio. Another example would be if the structure had failed then either an overlay or a recycling treatment could well be optimum. Experience and good historical records will reduce the need for numerical calculations.

9.4 Good records are also required to provide the knowledge of how long different treatments last in different situations. Table 9.1 gives some general guidance on the durability of treatments and also what they can and cannot do.

9.5 When the structure of the road is being improved it is difficult to forecast what improvement in life a given overlay provides unless the work is being carried out following a Deflectograph survey when the extension of life for a given overlay or the overlay for a given life extension can be determined using LR 833 [Kennedy and Lister 1978]. It may seem surprising to use such an old document but deflectograph still uses the research published in it and modern computer systems only compute the overlay required for a given traffic level and not the inverse. Further information on the structural contribution of thin surfacing is included in the supporting papers.

9.6 A useful flow chart that can be used to assist in choosing options can be found in HD 30/99 Figure 7.1.

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Treatment	Thickness range	Increase pavement strength?	Texture depth	improve Skid resistance	Reduce permeability of pavement	Improve ride quality	Initial cost	Speed of construction	Re-profile	Noise reduction	Expected life	Level of sustain-ability
	mm	Yes/no	mm								years	Range -- 5 to + 5
Patch (with no other treatment)	Any	No	No	No	No	No	Very high	Slow	No	No	0-3	-- 2 to -- 4
Retexturing	0	No	1.5	Yes in medium term	No	No	Low	Fast	No	No	3 then re-do	+ 3 to + 4
Surface dressing	6-14	No	1-3	Yes	Yes (best)	No	Low	Fast	No	No	10-15*	+ 4
Slurry surfacing	6-15	No	0.5-1.5	Yes	A bit	Can do	Moderately low	Fairly fast	Yes	No	5	+ 2
SMA surfacing	30-70	Yes	0.5-2	Yes	Usually	Yes	Medium to high	Moderate to fast	Yes	Yes	15+ at 4% void. 8 at 8%	+ 2
55% hot rolled asphalt	30-70	Yes	0.3-1	Yes	Yes	Yes	Medium	Moderate	Yes	Yes	10-15	+ 2
30% hot rolled asphalt	40-50	Yes	0.5-1.5	Yes	Yes	Yes	Medium to high	Moderate	Yes	No	12-16	+3
High friction systems	3-5	No	0.5-1	Yes (best)	A bit	No	Very high	Slow	No	No	3-10	-- 5
Structural overlay	80+	Yes	Depends on surfacing	Yes	Yes	Yes	High	Slow (to moderate)	Yes	Depends on surfacing	20+ for structure	+ 4
Haunching/strip widening	80+	Yes, locally	Depends on surfacing	Depends on surfacing	Yes	Yes	Medium to high	Slow (to moderate)	Yes	Depends on surfacing	20+ for structure	--2 to + 2
Retread with 2 surface dressings	75-100	Yes	About 1	Yes	Yes	Yes	High	Fairly fast	Yes	No	10+ (as structure)	+ 3
Deep recycling with foamed bitumen	150-250	Yes	Depends on surfacing	Depends on surfacing	Yes	Yes	Very high	Moderate	Yes	Depends on surfacing	20+ for structure	+ 4

*when done to current Warwickshire standards. Since using end performance specification the early failure rate has tended to increase.

Table 9.1 Treatment options

10 Surfacing and overlaying

Introduction

10.1 Surfacing is required to perform four main functions in various combinations. Each surfacing type has its own strengths and weaknesses and no single surfacing type is best in all situations. The four functions are:

- to waterproof the pavement structure,
- to add strength to the pavement structure,
- to provide good ride quality and
- to provide adequate skid resistance (this includes macro-texture where required).

For more details on these subjects see appendix A to this chapter and for a short discussion on skidding resistance see Appendix B. For the specification of PSV and Aggregate size combinations see Annex B to this strategy.

10.2 The County has a limited budget for road maintenance and the aim should always be to maximise the long term value obtained from that budget. The first choice maintenance option should always be surface dressing as it is the pre-eminent surfacing for waterproofing the structure and is equal to any for providing skidding resistance. Only if it is necessary to add strength to a pavement structure or to improve ride quality would a paver laid surface be considered. For residential roads slurry surfacing can improve ride quality but not as well as paver laid surfaces and does not improve the pavement strength.

Surfacing on lightly trafficked roads

10.3 Lightly trafficked roads are those categorised as type 4 in the New Roads and Street Works Act; ie those carrying up to about 100 cv/l/d. In the normal road hierarchy this type will include virtually all D (unclassified) roads (98.4%) and many C roads (87%). As can be seen from the summary table the preferred surfacing type on these roads is 55/10F hot rolled asphalt for all the different options of rural or urban situations. Other surfacings may be used but only where there is justified need which shall be recorded as part of the design process. This is most likely where there are particularly onerous environmental considerations (mainly noise on higher speed roads).

Surfacing on other roads

10.4 The surfacing on more heavily trafficked roads shall be either 55/10F hot rolled asphalt or an SMA to 976AR. Other surfacings, including 30/14 HRA Rec with 20 mm precoats may be used but only where there is justified need which shall be recorded as part of the design process. On roads carrying more than 100 cv/l/d with a speed limit above 40 mph the first choice surfacing material would be SMA 10 (surf) to BS EN 13108-5 and PD 6691. Specifications for SMA surface course are given in Part 3 – 976AR. HAPAS surface courses may be used but only those that comply with the compaction requirements of clause 973AR are permitted. A choice of binders is given in clause 976AR. For normal use either 65/105-45 or 75/130-45 may be used. Some binder suppliers supply one of these and some the other. The other binder, 75/130-75, is a high performance binder and its use will be limited to sites where its resistance to crack transmission is needed.

Overlaying

10.5 Where more than a single layer of surfacing is required a number of options are open depending on the category of road and the thickness required. For roads carrying significant traffic the overlaying will normally be carried out in 2 or more layers with the surfacing as above but the additional layers would normally be AC20 dense bin 100/150. On very lightly trafficked roads a combined layer consisting of either 55/10F hot rolled asphalt (up to about 70 mm maximum) or, currently being trialled, 20 mm SMA to BS EN 13108-with polymer modified binder which may be used for a single structural/surfacing layer between 60 and 100 mm thick. With current knowledge it

should be limited to roads carrying less than 100 cv/l/d. There have been a few reported problems with horses slipping on it so care should be taken when using SMA on horse routes so gritting during laying could be considered where there is significant horse traffic. Historically Warwickshire has used a 60-80 mm thick layer of 20 mm dense asphalt concrete with an additional 0.5 % of binder. Provided the correct PSV is specified then it performs as a surface course. It may need a surface dressing with a few years which should use 6 mm chippings.

Bond Coats

10.6 Bond coats shall be polymer modified bitumen emulsion as set out in BS 594987:2015. The minimum rate of spread shall be 0.3 kg/m^2 residual on new untrafficked layers and 0.4 kg/m^2 residual on planed and other substrates subject to a suitable increase on porous and high textured surfaces (see table 10.1 for equivalent spray rates needed to obtain these residual binder rates. In any case the minimum bond strength shall be 200 kPa within 1 week of laying. The bond strength shall be assessed in accordance with clause 975AR. In all cases of doubt the torque test shall be used. On class D roads the bond coat shall be sprayed not earlier than 24 hours before laying commences (with careful planning this enables two days laying to be sprayed on 1 visit of the spray tanker). However on class C or higher class roads spraying shall only take place after the road has been closed to public traffic. This is to ensure that the bond coat is not worn away by traffic and therefore rendered ineffective.

Table 10.1 Rate of spread of bond coat

Class of polymer modified bitumen emulsion	Residual binder 0.3 kg/m^2	Residual binder 0.4 kg/m^2
C50PB	0.6 l/m^2	0.8 l/m^2
C60PB	0.5 l/m^2	0.67 l/m^2
C65PB	0.46 l/m^2	0.62 l/m^2

The polymer modified bitumen emulsion shall have a minimum cohesion of 1.0 J/cm^2

High friction surfacing

10.7 ***There is rarely justification for this type of surfacing in Warwickshire***. High friction surfacing shall only be used for reduction of skidding crashes and not for any other purpose; it is very expensive, often has the shortest life of any surfacing and has a very high environmental cost. Before using high friction surfacing on an existing road (eg where the site category has been increased by installation of a pedestrian crossing) the existing skidding resistance must be checked, either from existing data or a specific Grip Tester survey and repeated in the summer following installation; only if there is a demonstrated need should high friction surface be used although there may be need for some enhancement of skidding resistance. Surface dressing can usually be used to provide this enhancement with a suitable design. See chapter 16 for more information on specifying and laying High Friction Surfacing. See also the Skid Resistance Strategy for the procedures to be used to assess skid resistance. ADEPT guidance states the High friction surfaces are rarely needed on Local Authority roads.

Coloured surfaces

10.8 Coloured surfaces are useful for various traffic management purposes but they should only be used where their need is demonstrable. More information on ways of obtaining coloured surfaces in given in Appendix C to this chapter.

If it is necessary to provide a coloured surface there are a number of naturally occurring coloured aggregates in the UK that could be used and these provide colours that are not bright and glaring and they could be incorporated in surfacing materials which would have long life and would maintain their colour throughout their lives. [Nicholls 1998].

10.9 Calcined bauxite must not be used in a coloured surface unless its high friction performance is required.

NOTE: some authorities are removing coloured surfaces from areas such as bus lanes and cycle paths and are finding that this has no effect on their use.

Table 10.2 Summary of first choice surfacing types to be used (other than surface dressing)

	Traffic level	**0-20 cv/l/d**	**20-100 cv/l/d**	**More than 100 cv/l/d**
Speed limit	*Road type*	*HAUC type 4*	*HAUC type 4*	*HAUC type 3 or above*
50-60	*Single track*	55/10F-125	55/10F-125	n/a
50-60	*Two lane*	55/10F-125	55/10F-125	55/10F-125 or 10 SMA to BS EN 13108-5** PMB
50-70	*Dual carriageway*	55/10F-125	55/10F-125	10 or 14 mm SMA to BS EN 13108-5** PMB
40	*Two lane*	55/10F-125	55/10F-125	55/10F-125
40	*Dual carriageway*	55/10F-125	55/10F-125	55/10F-125
20-30	*Cul de sac*	55/10F-125 or slurry surfacing*	55/10F-125	n/a
20-30	*Residential*	55/10F-125	55/10F-125	55/10F-125
30	*Through route*	55/10F-125	55/10F-125	55/10F-125

* the slurry surfacing shall be to BS EN 12273 with the appropriate specification of performance related parameters and shall be designed to take a high proportion of slow speed (including stationary) power steering..

** where the existing structure is sound which means uncracked, any rutting is in the surface course only and there is at least 15 years structural life remaining across the whole carriageway. Otherwise use surface dressing to maintain waterproofness until such time as funds are available to restore the structure.

55/10F-125 is short hand for: Hot Rolled Asphalt 55/10F surf 100/150.

Surface dressing may be used on any class of road provided it is correctly designed and if structural improvement is not required

10.10 When resurfacing with hot paver laid materials any ironwork within the carriageway shall be reset to its final level before the surface course is laid. If for some very good reason this not done then the area around the ironwork which is cut out in order reset it shall be reinstated with a HAPAS certificated inlaid crack sealing system (eg Permatrack – HAPAS certificate number 02/H072). On no account shall the hand laying of thin surfacings be attempted as they always fail very early.

NOTE: 'Permatrack' is given here as an example for information. It cannot be specified as such as that would contravene the Public Procurement Directive (PPD)

Appendix A to Chapter 10

Surfacing Capabilities

Waterproofing the pavement structure

10.A.1 It is very important to keep water out of the pavement structure. The first line of defence in this respect is the surface course. Surface courses vary considerably in their ability to waterproof the pavement. In general the richer the mixture and the lower the void content the better the waterproofing ability of the material. The pre-eminent surfacing in this regard is surface dressing because it has a continuous thick binder film across the whole road; it is almost totally waterproof unless there are unbridgeable cracks in the existing road. Hot rolled asphalt, of any stone content, is also very good. The thin surfacing materials are very variable in this respect; some are very good either because they have low voids or they have a thick bond coat whereas others are quite permeable. Asphalt concrete surfacings are poor in this regard which is a factor contributing to their non-use in Warwickshire. Even the so called dense macadam surfacing is quite permeable and the close textured ones certainly are. Slurry surfacings are also relatively permeable as they need moderately high voids to allow the water involved in their binder to escape although they become significantly less permeable with time. Porous asphalts by their nature are very permeable.

Adding strength to the pavement

10.A.2 Most hot dense surfacing materials add strength to the pavement structure. Surface dressing and slurry surfacing do not add any strength. Thin surfacings are very variable in this regard, some add significantly to the pavement structure while others have no significant effect. Hot rolled asphalt also adds strength. What is indisputable is that these strengthening effects are only valid where the pavement is in a sound structural state. **No surfacing of any type can rescue a failed road**. Resurfacing a failed road may hide the defects for a few weeks, a year at the outside for lightly trafficked roads. The structural contribution from porous asphalt and asphalt concrete surfacing should be ignored.

10.A.3 If a higher level of strength improvement than is given by a standard surfacing is required then either a thicker layer of 55/10 asphalt or a thick layer of proprietary strengthening surfacing (eg Ultiflex) may be used. As an alternative a binder course plus surfacing combination may be used.

Improving ride quality

10.A.4 Only paver laid surfacings provide good ride quality. Surface dressing has no effect on this parameter. Slurry surfacing can improve the quality where the irregularities are short wavelength such as on roads where utility reinstatements are numerous and poor. Paver laid thin surfacing is particularly good in this regard as they are usually quieter than traditional materials and are usually perceived by motorists as more comfortable than a noisier surface with the same level of irregularity.

Providing adequate skid resistance

10.A.5 This is the surface parameter that contributes most to road safety. There are two fundamental misconceptions with this parameter: PSV is usually thought to be synonymous with skidding resistance – it is **NOT**; and that the higher the skidding resistance the lower the crash risk. This latter is only true at low levels of skidding resistance; once the skid resistance level reaches a threshold (which varies from site to site) skidding crash rates do not reduce further

and may increase. Too high a skidding resistance usually means that resources have been wasted. PSV usually contributes to skidding resistance but aggregate size, traffic flows, time of year and site layout contribute usually more variability to the skidding resistance of a site. PSV and aggregate size are controllable inputs whereas all the others are beyond the control of the maintenance engineer but can be designed for. Site layout is changeable in the long term but is an expensive option. In 30 mph areas in Warwickshire it has been shown that there is no effect on wet skid rate with CSC (Characteristic SCRIM Coefficient) down to as low as 0.28. [Catt 2011]

Note: PSV is in the process of being changed across Europe to FAP (friction after polishing) previously called 'Wehner Schulze' test. The correlation between MSSC and FAP is non-existent on UK roads (R^2 was 0.037). See Project No. 41. Code of Practice of Skid Resistance for Local Authority Roads (CSS (ADEPT) 2009)

Other factors

10.A.6 The above factors are not the only ones to be considered although they are the main technical ones. Other factors that need to be taken into account are:

- Appearance – particularly in town centres, villages, conservation areas and other environmental sensitive situations. Evenness of appearance comes high on the list of priorities for acceptability of a road surface it is higher than ride quality for residential areas where heavy traffic is uncommon. Multiple patching has very low acceptability even when very well done.
- Colour is also part of appearance but can be determined separately. The most durable colours are those where the aggregate is used to provide the colour rather than using pigments. Colours provided by aggregates are much more easily matched for repairs or extension of the surfacing as they are inherent in the material and do not degrade with time and aggregate from the same source is normally of the same or a closely toning colour. See also Appendix C to this chapter.
- Time of year – some surfacings cannot be laid in winter – eg surface dressing. Others, such as high friction surfacing and micro-asphalt (slurry surfacing), **should not** be laid in Winter as the likely failure rate will be high..
- Noise – in noise sensitive areas the likely noise generation should be part of the design process. 55/10F HRA is a reasonably quiet surface and for lightly trafficked roads and those with a 30 mph speed limit or lower there is no noise justification for using a thin surfacing; there could just be a marginal justification on more heavily trafficked roads where the 30 mph speed limit is routinely exceeded. Poor reinstatements can excite high levels of impact noise particularly when traversed by empty lorries
- Cost is obviously a consideration, but only in conjunction with expected life, all the other factors should be considered first and a **best value** surfacing should be arrived at.

Appendix B to Chapter 10

Summary of factors affecting skid resistance

10.B.1 There are a number of factors affecting the skidding resistance of any particular location of which polished stone value is only one, and not always the most important one.

10.B.2 The major ones with an estimate of their potential relative effect on skid resistance is given in table B.10.1

Table B.10.1 Relative effect on skid resistance of various factors

Factor	% change in SCRIM coefficient from highest to lowest	Notes
Time of year	15 or more, the extreme so far is 28	Skidding resistance is lowest in mid to late summer. Weathering in winter, polishing in summer
Aggregate size	20	3 mm highest skidding resistance, 14 and 20 mm lowest skidding resistance.
Change of skidding resistance with speed on low textured surfaces eg 55/10 asphalt	9 (locked wheel) the effect is less with rolling wheel	Drop in skidding resistance from 30 mph to 60 mph. Below 30 mph skidding resistance increases with low texture*
Change of skidding resistance with speed on high textured surfaces eg racked in surface dressing	2 (locked wheel) no effect with rolling wheel	Drop in skidding resistance from 30 mph to 60 mph
Traffic level (0-250 cv/l/d)	14	This is the drop between no traffic and 250 cv/l/d. Additional polishing due to increased commercial traffic only. Little change above this level of traffic.
Turning and braking	6	Difference between no stress and turning and braking due to additional polishing action
PSV	17	Range normally used in surface courses (55-65)

* recent research has shown that for 6 mm and other small sizes the drop of skidding resistance with speed is much smaller.

10.B.3 A more detailed paper in included within the supporting papers.

Appendix C to Chapter 10

Coloured surfacings

10.C.1 There are many coloured surfacings on the market. They are based on one of two means to provide it: either by the use of pigments or by the use of coloured aggregates; sometimes both methods are used.

10.C.2 When made with uncoloured binders pigmented materials are often brighter initially but are prone to fading unless inorganic pigments are used. However many inorganic pigments are based on heavy metal compounds eg chromium or cadmium salts which are toxic. The traditional coloured materials are coated bituminous materials pigmented with iron oxide (non-toxic) but this gives a muddy red brown colour because of the black binder used. They are relatively durable although usually somewhat less so than the equivalent unpigmented materials; this is due to the higher fine filler content. Any pigmented material that is used must use non-toxic pigments as there is always wear to the surface which generates respirable dust and disposal when the coloured surface is removed is very difficult and expensive and getting more so.

10.C.3 Organic pigments are usually non-toxic and when used with clear binders can be initially very bright but often fade very quickly. Because of this fading it is very difficult to match colours if remedial works have to be carried out. Pigmented materials are often hand screeded which exacerbates the matching problem as texture can vary from screed to screed and this has an apparent effect on colour. Screeded materials usually have poor durability as they tend to debond early with the process often starting in less than a year. They are also very expensive both in first cost and maintenance cost. All pigmented materials and particularly screeded ones should be avoided unless no other process is usable.

10.C.4 Whether pigments are used or not the ultimate colour of any surfacing is that of the aggregates that are contained within the material. The colours of aggregates do not fade (they are geologically old) and matching is easy – as long as the aggregate comes from the same source – the blending in is usually very good. They can also be used in durable materials and processes such as surface dressing (preferred as the colour is there from day 1) or coated materials. If the coated materials are made with a clear resin the colour is again available from day 1. The cheapest and most durable option is to use a coloured aggregate in a conventional bituminous material but the colour takes time to develop; this option is of limited use for traffic management but may be of use in developments. See Bridgefoot in Stratford upon Avon for example of light aggregate in clear binder.

10.C.5 Where a particular colour is not required, eg as part of speed reduction measures then it is possible to use aggregates entirely from local sources. For example: on the usual dark grey of Warwickshire's road using either Bardon Hill or Bayston Hill aggregate a contrast can be obtained using Croft which is a reddish colour. This is a procedure used in Northamptonshire for many years where the rural roads were done in grey and speed limited areas in villages were done in 'red' (usually Croft). A trial has been done on the B4453 at Weston under Wetherley at the village gates at both ends of the village. The aggregate used was Castle an Dinas (very light grey) and was done at the same time as the main run of standard surface dressing through the village thus adding very little to the cost. See the grey/red difference in the surface dressing trial on B4451 between Bishops Itchington and M40 junction 12.

10.C.6 There are a number of coloured aggregates available and the currently known sources are summarised in table 10.C; there are probably others

Table 10.C Summary of coloured aggregates

Colour	Source	PSV	Comments
Green	Criggion, Shropshire	60*	This aggregate has been used in the County for many years and is still visible in a few locations
Green	Ghyll Scaur, Millom, Cumbria	67	This has been used a few times in County
Red	Harden, Northumberland	52	
Red	Brindister, Shetland Islands. (Imported into Kings Lynn)	64	Very little known about this source
Reddish	Croft, Leicestershire	56	See surface dressing trial B4451 for colour
Pinkish red	Wick, Near Bath	60	
Buff	China	70	Calcined bauxite, very high environmental cost. Use only where high friction is required
Light grey	Castle an Dinas, Cornwall	55	Other quarries in Cornwall may also have very light coloured aggregate
Various	Natural gravels	45 typical	May be suitable on very lightly trafficked roads.

* Often behaves as if the PSV were much lower than this – nearly all has been overlaid because of extremely low skidding resistance.

NOTE: The drive of Compton Verney House is an example of the use of natural gravel.

11 Haunching and strip widening

11.1 When the technique is used to add width to a road it is usually known as strip widening whereas haunching is the term normally used, particularly in rural areas, where the edge of a pavement fails long before the rest of the road, but the requirements are identical. It is usually very uneconomical, both financially and materially, to overlay the whole carriageway with enough material to prevent failure in these weakest areas at the edge of the carriageway. The cause of such failures is usually creeping widening of the carriageway over the years with material being placed in ruts at the edge where traffic has overrun and then subsequently surface dressed and patched and surface dressed again. Haunching and strip widening are always built to full construction depth for new work even though this is usually thicker than the existing. The existing has usually had many years of compaction and adjustment to construction which the new work has not and also the new work forms a support for the rest of the road width.

11.2 Haunching consists essentially of the reconstruction of about a metre width (usually between a minimum width of 1 m and up to 2 m) along the edge of the carriageway cutting back into sound construction. The edge of the excavation should be stepped so that when the haunch is rebuilt the new work is married into the old in such a way as to minimise the likelihood of water penetration. The outer edge of the excavation must be wide enough so that when it is backfilled with stone the final carriageway is supported at an angle not less than 45º to the horizontal; ie if the excavation is 700 mm deep it shall extend at least 700 mm beyond the final edge of the carriageway. If this is not done failure of the new edge will occur fairly rapidly after reconstruction. This width shall take into account any additional thickness added by means of an overlay over the whole width.

11.3 Once the sub-base is in place – the thickness required shall be that described in Chapter 2 under ‘new construction’ – all further layers shall be laid by machine (except for the rare instances where this is impossible). The surface course of the haunching shall always be machine laid even when subsequent overlaying is expected. The steps against the old construction shall be coated in bond coat both on the horizontal and vertical faces to ensure that the whole construction becomes a monolithic whole. Any joints in the surface course must not be in the wheel tracks even if it means planing out a little more existing surface course which is most likely to occur when a new turning lane is being installed.

11.4 Avoid narrow or tapering strips as it is very difficult to compact any layer within them (a minimum width of about a metre should be aimed for). Where a turning lane is installed all longitudinal joints in the final surface course should be along the lane lines with any width variation in the centre of the road. The through lane must not have any diagonal joints.

11.5 Where overbanding is used it must be a textured antiskid type with a HAPAS certificate. This type of overbanding is much safer for two wheeled traffic than the traditional smooth type. These traditional types of overbanding must not be used in any circumstances, traditional overbanding is very poor at joint sealing as it cracks in the first winter due to thermal movement, good treatment of the vertical joint is much more effective as a seal. Some of those with HAPAS certificates are also designed with joint sealing in mind and that type is preferred as they are more likely to be durable. They are also tougher and less likely to bleed through surface dressing.

12 Patching

12.1 Within Warwickshire patching is used in two distinct ways. The first is to make the road safe and this is often done by the safety inspection teams who cover the county highway network in a standard manner or as result of information received from the public. The other is planned patching which takes place where a road is showing signs of distress but is not dangerous. Whenever a road needs patching a record of the cause or causes and an assessment of the likelihood of further patching in the vicinity must be undertaken.

Safety

12.2 Small areas of loss of material must be filled quickly if they constitute a hazard. These are defined in the county maintenance policy. Where the pot hole is in a place where the road is habitually crossed by pedestrians – eg at junctions, outside churches, chapels, meeting halls etc the possibility of it also being a trip hazard should be considered and perhaps a speedier response than would normally obtain may be necessary. Alternatively the filling of potholes smaller than would normally be the case may be needed. Either bagged material or deferred set materials may be used. Often these have short life (although this seems to be improving, particularly with bagged materials) and the patches may need redoing at intervals until the proper planned patch or other treatment is carried out. In any case good compaction will prolong the life of the patch, rolling with the wheels of a vehicle may well provide better compaction than a hand punner provided that care is taken to maintain reasonable surface regularity.

Planned patching

12.3 Planned patching may be carried out for a number of reasons:

- Prior to surface dressing or other resurfacing
- To rectify problems with utility reinstatements
- To extend the life of the pavement structure. A benefit/cost assessment, including the likely cost of further patching from the same cause, should always be carried out before this reason is acceptable as patching is often a very expensive exercise in terms of unit cost.
- When resetting ironwork that has sunk, is rocking or has failed in some way and is being replaced.

12.4 Planned patching should be carried out as early as possible after marking out – our customers are not impressed by yellow lines fading with time and nothing being done. The patch shall be set out so as to include all of the pothole plus any area likely to fail within the foreseeable future. The outer edge of reinstatement shall be at least 100 mm beyond the edge of the current pothole. If there has been any delay in carrying out the reinstatement the area shall be reassessed immediately prior to reinstatement and if the pothole has enlarged, as is likely if the reinstatement has been delayed by more than a week or two, then a larger area shall be treated to include the whole of the damaged surface.

12.5 All vertical faces shall be sawn and the layer removed up to the saw cut. The preferred option is to remove the material using a planer to avoid the use of vibrating hand tools; planers specifically designed for this purpose are now widely available. A planer removes a more consistent thickness which improves the quality of the reinstatement. Where a planer is used it is not necessary to saw cut as a planer leaves a sufficiently neat edge. Where more than one layer is being reinstated the surface course shall be cut through and removed and then the binder course layer saw cut at least 75 mm smaller all round and then the failing binder course should be removed. Again both layers can be taken out by a planer but still leaving a 75 mm wide step at the base of the surface course.

12.6 Where saw cutting takes place as a separate operation ahead of the reinstatement it should not be done more than a few days in advance as the cuts allow ingress of water into the structure. If a two course patch is required then the advance cutting shall be one shallow cut (approx 40 mm) around the outside and a concentric deeper cut 75 mm (or more) inside it to the depth of the bottom of the binder

course. Where determinable, whole layers shall be removed with a minimum of 40 mm for surface course patches.

12.7 The whole of the horizontal and vertical faces shall be coated with a suitable bond coat. Overbanding shall not be used except where the existing surface is in danger of fretting when a band not exceeding 40 mm wide may used with at least two thirds of its width on the existing surface course. Its purpose is purely to assist in preventing further deterioration; Overbanding does not seal a joint for very long as the joint propagates through and the overbanding cracks. Overbanding shall never be used if the road is going to be surface dressed within the next two years. See also under strip widening)

12.8 Reinstatements, when hand laid, shall use hot rolled asphalt 45/10F surf 160/220 clause 970AR. This may be used for the whole depth of a reinstatement provided that it is laid in layers not exceeding 60 mm and each shall be fully compacted before the next layer is placed. Where the material in a layer is still warm to the touch when the next layer is placed there is no need to use a bond coat between layers, although that would still be preferred as good practice [Road Note 42]. However if, for example, the binder course is left overnight before the surface course is laid the binder course shall be sprayed with bond coat before placing the next layer. Where patching is extensive it may be better, technically and visually, to use a mini-paver for laying material in which case hot rolled asphalt 55/10F surf 100/150 should be used.

12.9 Permanent reinstatements shall not use deferred set or cut back materials. Asphalt concretes to EN 13108-1 shall not be used as surfacing. Although they often appear to be more workable than 45/10 asphalt they are much more permeable even when well compacted and do not match any surfacing used in Warwickshire for over 25 years. . Asphalt concretes should not be used as patching materials in preparation for surface dressing as they are usually more porous than the existing surface. Therefore, some of the surface dressing binder will be absorbed into them thus leaving insufficient binder within the patch to retain chippings. If used prior to surface dressing macadams, even close textured or dense ones, are more porous than existing surfaces whether they are asphalt or surface dressing and it is likely that a local failure over the patch will ensue as there will be insufficient binder to retain the chippings within the area of the patch. There is currently no suitable patching material which will give reasonable match to any of the HAPAS thin surfacings and on no account shall hot thin surfacing material be hand laid as they are totally unsuitable for this purpose because of their very high stone content and hard binder.

12.10 New patching materials are being developed but are as yet unproven. Their use shall be limited to fully monitored trials unless they have a HAPAS certificate when they may be used within the certificated limits.

12.11 Where there is a structural failure then the patch shall consist of 200 mm of bituminous material or the thickness of the existing pavement if greater. This material may be 45/10F or 55/10F asphalt (as appropriate to the laying method) but if the area is extensive it may be better to use AC20 dense bin 160/220 for all but the surface course.

Patching on pavement edges

12.12 Patches at the edge of unkerbed pavements shall follow the general requirements for patching given above but care shall be taken to ensure that the road width is not increased, ie the outer edge of the patch shall be in line with the rest of the road edge. If it is necessary to add support to the edge of the road because traffic has overrun and caused significant rutting then the ruts shall be excavated to a depth of 300 mm and to a minimum width of 300 mm and backfilled with suitable free draining crushed rock such as W75 or coarse bituminous planings to a level approximately level with the road edge and then some verge material shall be placed on top so that it does not look like a widened pavement.

Patching round ironwork

12.13 Patching around ironwork is probably the most difficult type to do successfully and durably. The most important factor is to ensure that the cover is properly and firmly but resiliently set. If this is

not done and there is even the slightest degree of rock the reinstatement will fail rapidly. Therefore stage one is to reset the ironwork in a sound manner. By far the best is to use a resilient material to set the frame. There are a number of proprietary systems on the market, not all of which are suitable for maintenance purposes. If the traditional cement mortar approach is used then it shall not be made too strong and thin pieces of build-up such as tile shall not be used as they cause rapid failure.

12.14 Once the frame has been set and any build up material set sufficiently to carry traffic without movement (this may be overnight with cement based materials) the reinstatement of the surrounding area may be undertaken. It is most important that this is done in such a manner as to minimise any possible ingress of water. The whole of the surface of the iron frame (except the top) shall be fully coated in a suitable bond coat – both vertical and horizontal surfaces, the vertical face of the surrounding pavement structure and any visible horizontal pavement structure shall likewise be coated. The reinstatement shall be carried out using hot rolled asphalt 45/10F surf 160/220 (Annex D). On heavily trafficked roads or where the ironwork is in a wheel path 100/150 grade binder may be used to limit deformation. Even more likely to be durable are HAPAS inlaid sealing materials certificated for the thickness and width to be used.

NOTE 1: 'heavy' in this context means HAUC types 0 or 1 roads.

NOTE 2: on roads less than 6.7 m wide even gullies are in the wheel path of heavy vehicles.

12.15 There are number of new processes coming on to the market specially designed for ironwork reinstatement and trials should be carried out on a representative selection of suitable ones.

Last amendment July 2015

13 Traffic safety

13.1 Traffic safety interventions includes various modes of traffic management introduced for purposes such as collision reduction, speed reduction, and environmental improvement. These are all regarded by the public as being aspects of traffic calming regardless of the reason for the intervention.

13.2 When traffic calming is introduced on a site the design should be based on the whole life cost of the scheme and not just the initial cost. This is in line with asset management principles.

13.3 Examples of factors that shall be taken into account are:

- Initial cost
- Decreases in structural life downstream of humps, cushions and transverse road markings due to increased dynamic loading
- Increased routine maintenance costs due to factors such as the need to sweep by hand between 'build outs' and existing kerbs
- Need for higher PSV aggregates because of the increase in investigatory level caused by turning and braking
- Maintenance costs such as need to replace road markings on a regular basis (life expectancy of white lines about 4 years or less) and the need to remove them in their entirety before resurfacing.
- Damage levels to street furniture and signs which in some cases can be frequent.

13.4 There is guidance within the Local Transport Note 01/07 Traffic Calming [DfT] on the use of traffic calming on new estates.

13.5 High friction surfacing should be used only where its skid resistant properties can be demonstrated as likely to reduce casualties but not otherwise. With the traffic levels on Warwickshire's roads it is very rare that high friction surfacing is needed. For further information on specifying and laying High Friction Surfacing see Chapter 16. See also ADEPT guidance which says the need for HFS is rare of Local Authority roads. In IAN156/12 [HA2012] the highways Agency does not require High Friction surface (HFS) in any circumstances on roads carrying less than 750 cv/l/d except on defined high risk sites with very high crash rates.

13.6 A full justification in terms of collision reduction shall be carried out before high friction surfacing is used. Annex B gives the equivalent Polished Stone Values for different aggregate sizes for various situations. As can be seen the use of aggregate smaller than the standard 20 mm on which Highways Agency advice is based can be used to provide more than adequate skidding resistance. For example the use of 6 mm size promotes a 60 PSV aggregate to the equivalent of about 74 which is more than adequate for virtually all sites, although a more conservative value is used in Annex B.

13.7 Sections using coloured surfacing are frequently used within these areas particularly as passive speed control devices within villages (Village speed limit review). Currently these are often provided using a screeded surface which usually incorporates calcined bauxite utilising either buff bauxite to provide colour contrast or are pigmented in addition to highlight a possible hazard. Calcined bauxite has the highest environmental cost of any aggregate (and possibly of any material) used on UK roads. The calcining process takes place at 1700ºC which is obviously very energy hungry and the process itself, particularly that used in China, is also heavily polluting of the local area in terms of smoke generation (serious health problems have been unofficially reported). Therefore, wherever possible, naturally occurring UK aggregates shall be used, there are a number of suitable aggregates available which would contrast with the normal dark grey which is used most often Warwickshire. See also Appendix C to Chapter 10.

NOTE: for example pink granite from Croft could be used to contrast with the grey of Bardon Hill.

13.8 Pigments also carry a risk as some are toxic and care must be exercised to ensure that toxic pigments are never used. The problems arise in the production of dust as they wear and their removal at the end of their life which can spread toxic materials far and wide.

13.9 Whenever a high friction surface has been used for colour and not its high friction properties there is a significant risk of poor safety. Examples of unsafe use are: use on part width of a road such as in a cycle way at a side junction or it has a significant area of white marking on it. The aim should be to maintain an even level of skidding resistance across the whole lane (or potential lane – eg where traffic can move into a cycle way).

13.10 Where a full lane width is not treated it is quite likely that a vehicle braking will have one side of the vehicle on a normal surface and one side on a high friction surface which could induce a spin on heavy braking especially on older vehicles without ABS or even, in the case of an articulated vehicle, jack knifing. Similarly screeded markings, whether white, red or yellow, have relatively low skid resistance and where they are placed on a high friction surface there could be the possibility of differential braking. There is a further hazard in this case and that is to motorcycles. If there is straight line braking then there could be sudden loss of grip as the front wheel moves from high friction surface to white marking possibly causing the rider to fall. It is possible that a sudden increase from low skidding resistance to high could also be a hazard. If this combination of high friction surfacing with low friction markings is used on a bend then a motor-cycle rounding the bend could slide on the white line and this would inevitably be hazardous [IHIE 2005]. A very high level of skidding resistance can increase the rate of crashes caused by skidding.

13.11 In all cases a full risk analysis, by a team independent of the design team, must be carried out to determine the overall safest combination of engineering measures.

Last amendment July 2015

14 Surface dressing

14.1 Surface dressing is the major maintenance operation, by area, carried out within the county. Warwickshire has a very good record of successful surface dressing and had one of the lowest failure rates of any local authority or contractor. This was due to the very close liaison between the client and the contractor which developed over many years. Almost all the failures that have occurred have been when the rules have been broken; for example when work has carried on into September or the work has been carried out when the weather has become unsuitable in order to finish a section. It has been calculated that rectifying a failure can cost between 5 and 10 times the original cost of the dressing. Risking failure can be very costly.

NOTE: There is scope for improving the durability of surface dressing by increasing the rate of spread of binder above that given in Road Note 39. There is very little record of fatted up surface dressings in Warwickshire since the switch to polymer modified binders and the more binder there is on the road the more durable is the dressing going to be. The overall aim should be an equal number of ultimate failures which are due to fatting up and to fretting although the majority should always be by overall wearing out.

14.2 The type of contract for surface dressing has changed since the 2009 edition of this Strategy. It is now a performance based specification using clause 922 of the SHW. The main requirements are:

1. The contractor must have a CE mark covering all the types of surface dressing that he intends to use. This must be to BS EN 12271.
2. The contractor is required to provide his design procedure; this will often be Road Note 39 but any documented method may be used.
3. The client must set out any limitations of binder types and grades, aggregate sources and characteristics (PSV, AAV etc) and minimum strength of dressing required, eg racked in or double.

All these should be set out in Appendix 7/3 of the contract. An example of this is given in part 3 of this document. There may be variations in the new contract starting May 2016 – any variations needed should be set out in the contract.

Also set out in the same appendix is the information that must be provided by the contractor prior to work starting. In general all the information is similar to that shown in the draft Appendix 7/3 in the Specification for Highway Works volume 2.

14.3 Not all the options given in Road Note 39 are now permitted in Warwickshire. The main limitations being:

- Emulsion binders shall be used unless there are development in the use of plant based fluxes which gain strength by the flux hardening and not by flux evaporation as is the case with conventional cut-backs.
- Only polymer modified binders shall be used (premium or super-premium grade as appropriate)
- No single layer dressings using 6/10 mm or 8/14 mm chippings shall be used
- 10 mm dressing shall be either racked in or double with the latter being used on higher stressed sites.
- 14/6 double dressings shall only be used where absolutely necessary – usually only lane 1 of heavily trafficked dual carriageways (eg Bedworth Bypass)
- 14/6 racked in surface dressing shall not be used (too noisy).
- Where the design method used permits a choice between 6/10 racked and single 6 mm dressings then single 6 mm would be the preferred process because of the higher skidding resistance likely to be provided with the smaller aggregate.

Further technical information may be found in PD6689.

14.4 Successful trials have been carried out over the last decade or so into the use of the first sweepings from 10 and 6 mm dressings (mixed) on very minor rural roads. This should continue with great care being taken to ensure that the chippings are adequately clean for the purpose.

14.5 Where surface dressing is to be carried out over road markings they should normally be removed unless they are thin and outside the normally trafficked area. Surface dressing does not adhere well to thermoplastic lines. Not removing them in trafficked areas will result in a significantly reduced life as well as an uncomfortable ride which can lead to early structural failure because of increased dynamic loading. Any areas of horizontal road markings that need to be removed shall be set out in the contract. They shall always be removed in the following cases:

- Where new or revised traffic management is being carried out and traffic will travel over the area of the old markings – if this is not done traffic will try to avoid the unpleasant level of roughness and stray – for example – into a new cycleway included within the carriageway (eg B439, Evesham Road, Stratford).
- Zigzag lines, whether the ones outside schools or the no stopping ones adjacent to pedestrian crossings.
- Any other marking within the normal lane width if it has been applied more than once since last resurfacing – examples in this category include ‘slow down’ lines approaching roundabouts and junctions, dragon’s teeth, 30 mph roundels.

NOTE: For many years virtually all the surface dressing binder has been obtained from a single source (Lanfina, now Total Bitumen)**.**Total’s intermediate grade binder normally complies with premium grade requirements, therefore care must be taken when trying other sources to ensure they are as robust.

Last amendment July 2015

15 Slurry surfacing

15.1 Slurry surfacing is the generic term for surfacing materials which are mixed on site in the form of a slurry and are then screeded out to form a new surface. The thinnest options are sometimes called slurry seals and the thicker ones are usually called microasphalts (or micro-surfacing). The main ingredients are graded aggregates and bitumen emulsion which is often polymer modified. Other minor constituents, used for modifying the mix for different substrates or different weather conditions are water, cement, 'dope' and fibres.

15.2 Considerable development has taken place in this type of material in the last few years and at the highest performance level a HAPAS certificate had been achieved by at least one material as a fully fledged thin surfacing and, at the other end of the spectrum, are simple volume batched materials suitable for footways. Most frequently slurry surfacings have been used successfully on footways and lightly trafficked, low speed roads. Most of the successful ones contain either polymer modified binder or fibres or both.

15.3 With the publication of BS EN 12273 HAPAS no longer applies as all the products within the slurry surfacing family must be to BS EN 12273 and be CE marked which includes installation. The contractor must have a quality assurance scheme compliant with BS EN 12273 as part of the CE mark requirements.

Road use

15.4 Slurry surfacing using 0/6 mm (or larger) aggregate may be used on lightly trafficked residential roads. The roads shall be limited to culs de sac and residential roads where the traffic is limited to that accessing properties along the road only. The material shall be specified and laid in accordance with clause 918 of the Specification for Highway Works. The requirements in table 15.1 shall be specified. See also PD 6689:2009 [BSI 2009]

15.5 Microasphalt has been used on a number of roundabouts in the last two years, early performance seems to be good but there is little information on the long term performance and durability in this type of situation. When more sites are treated they should be monitored together with those already done so that an appraisal of the economics of the process can be built up.

Table 15.1 Requirements for slurry surfacing for roads

Requirement	SHW table	Class or category
Macrotexture	NG 9/1	No requirement
Defect classification – area, P_1 to P_4 inclusive	NG 9/2	Category 2 for all P
Defect classification – linear	NG 9/3	Category 2
Transverse regularity	NG 9/4	Category 1
Longitudinal regularity	NG 9/6	Category 1

15.6 The slurry surfacing may be laid in one or more layers in order to achieve the required surface regularity, the lower layer or layers need not be complete but the final layer shall be laid over the entire area in widths one lane wide. Where the lane is too wide to lay in one width the joint shall be between the wheel tracks (ie in the 'oil lane').

Footway use

15.7 Slurry surfacing may be used for all grades of footway that have a bituminous surfacing. All the products within the slurry surfacing family must be to BS EN 12273 and be CE marked which includes installation. The contractor must have a quality assurance scheme compliant with BS EN 12273. The material shall be specified and laid in accordance with clause 918 of the specification for highway works. The requirements in table 15.2 shall be specified:

Table 15.2 Requirements for slurry surfacing for footways

Requirement	SHW table	Class or category
Macrotexture	NG 9/1	No requirement
Defect classification – area, P_1 to P_4 inclusive	NG 9/2	Category 2 for all P
Defect classification – linear	NG 9/3	Category 2
Transverse regularity	NG 9/4	Category 0
Longitudinal regularity	NG 9/6	Category 0

15.8 Where the slurry surfacing is used to seal the footway or to arrest fretting it may be laid in a single layer. Where regulation is required the slurry surfacing shall be laid in two or more layers with the final layer being placed using a screed of suitable width. The minimum thickness, at any point, of material in the final layer shall be not less than 1.5 times the upper aggregate size (eg for 0/6 mm material the minimum thickness shall be 9 mm). The target thickness shall be at least twice the upper aggregate size.

Last amendment July 2015

16 High Friction Surfacing

16.1 **It will be very rare for this surface type to be needed; it will have to be a very difficult site carrying more than 500 cv/l/d in any lane (in itself a rare traffic level in Warwickshire).** See also guidance from ADEPT. All high friction surfacing shall have a HAPAS certificate. All materials shall be laid by a HAPAS approved installer. As stated in 13.5 high friction surfacing should only be used where its skid resistance is demonstrably required, this is because it is very expensive and tends to fail 'catastrophically'; ie it delaminates from the underlying surface often within a year or two of laying. Maintenance will only be carried out when the skidding resistance falls below the appropriate investigation level and then only if the collision criteria are met.

16.2 High Friction Surfacings use calcined bauxite as the skid resistant aggregate which is either glued to the road surface using an adhesive such as epoxy resin (cold HFS) or is incorporated in a resin based mixture (hot HFS) which is screeded onto the road surface. Calcined bauxite uses huge amounts of energy in its production as the calcining process takes place at 1700ºC and the process used in China (the commonest source) is highly polluting. Guyana uses a cleaner process but both are produced a long way from UK and therefore they incur a high environmental penalty of long haulage. The properties of Brazilian bauxite are no better than some UK natural aggregates and, therefore, shall not be permitted.

16.3 High friction surfaces shall only be laid between May and September inclusive. It is an absolute requirement that they adhere strongly to the underlying surface (by definition they are subject to very high horizontal forces). Even a surface that is only very slightly damp (but which can be visually dry) reduces the likelihood of good adhesion occurring very significantly.

16.4 The ideal of naturally occurring complete dryness occurs only rarely between October and April. During this wetter period temperatures are also low which necessitates the use of screeded material. These have significant Health and Safety concerns which are such that Warwickshire should not be specifying them (even indirectly) as it may be in default of CDM regulations. WCC cannot stop a contractor using them but the safer option of sprayed and chipped versions of high friction surfacing should be available. It should also be remembered that screeded versions are often considered to have a poor appearance (important for good quality street scene)

NOTE recent research at TRL has confirmed earlier research that most of the advantage of calcined bauxite arises from its small size and the use of these smaller sizes of appropriate UK aggregate could be incorporated into suitable surfacing thus improving sustainability and reducing cost eg Tarmac's 'Friction Course'.

16.5 There is currently no national specification for workmanship on these products as there is for surface dressing and slurry surfacing. A combination of the visual assessments that are used for those two products shall be used for the assessment of High Friction Surfacing in Warwickshire. The test procedures to be used are set out in Appendix A of this chapter and the specification to be achieved is set out in Table 16.1.

16.6 The tests measure various factors of surface loss and fatting. Since these materials are, by definition, safety critical it is essential that they meet these requirements and any faults rectified.

Table 16.1 Specification for visual assessment of High Friction Surfacing

Parameter	Requirement in the wheel track*	Requirement outside the wheel track*
Fatting up after 2 weeks and any time up to 2 years; P_1	Not more than 0.5 %	Not more than 2.0%
Delamination at 2 years; P_2	Not more than 0.5 %	Not more than 2.0%
Chipping loss at 2 years; P_3	Not more than 3%	Not more than 6%
'Grinning' at 2 years; P_4	Not more than 3%	Not more than 6%

* Where the location of the wheel track is indeterminate, as on roundabouts, the whole area shall meet the wheel track criteria.

Appendix A to Chapter 16

Test methods for visual assessment of High Friction Surfacing

These are based on tests from BS EN 12272-2 and EN 12274-8 for surface dressing and slurry surfacing respectively which are already in use in the SHW for those materials. Minor modifications are needed to enable their use for high friction surfacing.

The four tests to be used are:

1. for fatting up – the test for fatting up EN 12274-8 (P_1 in that standard)
2. for delamination – the delamination test from EN 12274-8 (P_2 in that standard)
3. for chipping loss – the fretting test from BS EN 12272-2 (P_3 in that standard)
4. for 'grinning'* - the test for groups of small repetitive defects from EN 12274-8 (P_4 in that standard) except that the minimum defect size shall be 10 mm and not 10D.

* 'grinning' is where the high friction surface has worn off the top of chippings in the underlying surface and they are 'grinning' through the high friction surfacing.

17 Recycling

17.1 Any road in Warwickshire that was not constructed completely new in the last 30-35 years can be assumed to contain tar in one form or another either as the binder on base, binder course or surface course materials or as the binder in surface dressing. The last tar bound coated material was used on the A446 on Grimstock Hill on Coleshill Bypass around 1980 and the last surface dressing binder containing tar was used in diminishing quantities until 1989. From 1990 emulsion binders have been used exclusively. Therefore only in situ recycling shall be used unless the absence of tar can be demonstrated or a system and process used that takes the presence of tar into account.

NOTE 1: The Environment Agency has been known to permit ex situ cold recycling of tar bound materials but this should be checked with the local EA Office. They have published a Regulatory position statement. Version 3 was published in 2012 [Environment Agency 2012].

NOTE 2: The WRAP website has a number of useful papers [WWW.WRAP.org.uk]

NOTE 3: there are simple tests [Vansteenkiste and Verhasselt 2004] which can detect tar in cores taken from a road but they are not particularly sensitive ie when tar is detected it is definitely there; but at relatively low levels (although still above the threshold) the tests may not pick up the presence of tar.

17.2 It has been shown that cement based recycling is prone to severe cracking on clays and particularly on the Lias Clays of south Warwickshire whereas bitumen based ones tend to become wavy but remain intact. Therefore only fully flexible recycling procedures shall be used. The use of very low proportions of cement in combination with bituminous binders would constitute a flexible system.

NOTE: other binders are being developed such as various combinations of PFA/GGBS/Lime (hydraulic binders) most of which have intermediate flexibility but are very slow to gain strength and can fail if loaded early in their life.

17.3 On lightly trafficked roads the retread process has proved to be satisfactory over many years use both on residential roads and on rural roads when properly protected by at least two surface dressings or an impermeable surfacing like 55/10F hot rolled asphalt. It is essentially a simple process which involves breaking up the existing road structure to a depth of 75 mm to 100 mm (with modern plant it may be possible to treat up to 150 mm) adding bitumen emulsion and possibly some additional aggregate and mixing the whole together, screeding it out and compacting the whole and then covering immediately with a 6 mm surface dressing. It is best if a further 6 mm surface dressing is carried out in the following surface dressing season. If necessary a subsequent surface of 55/10F hot rolled asphalt may be applied. On rural roads without constraints on final levels it is likely that reusing the existing structure with a structural surfacing will be both cheaper and have a lower environmental cost over the long term, unless they are severely deformed.

NOTE: the ride quality is best if the breaking up of the existing road is done with a planer rather than with the more traditional harrows or tines.

17.4 This process is always carried out using specialist contractors as the experience of the gang doing the work and particularly that of the foreman is critical in making the difference between an adequate job and a good job. This is because the addition of binder and aggregate is a matter of judgement and not an exact science. Further information can be found in BS 434-2:2006.

17.5 On more heavily trafficked roads, or where a thicker treatment is needed, a foamed bitumen process may be used. This is in essence similar to retread but uses heavier plant similar to a road planer to break up the existing road and a heavy recycler which adds the foamed bitumen through an integral spray bar while the mixing process is taking place. As in the retread process the material is graded out and rolled. It is normally completed by placing a surfacing layer of 55/10F hot rolled asphalt at least 40 mm thick on top. In urban areas it will usually be necessary to remove some 50 mm of the existing road structure otherwise the final surface will be too high. This process is only carried out by a limited number of specialist contractors. The equipment is heavy and expensive to move so it is only economical where a suitably large area can be treated as a single contract.

17.6 In urban areas where there has been significant activity by the utilities care must be taken to assess the suitability of a multitude of materials for use in the process.

Last amendment July 2015

18 New materials and processes

18.1 Warwickshire has a long and proud history of trialling new and innovative materials and processes. Some of the highlights are:

- 1965 Open graded sub-bases – W150 and W75 started life on Warwick Bypass as 4½" (112 mm) crushed concrete, screened into two fractions, which was won primarily from a wartime airfield at Atherstone on Stour just outside Stratford. This was also a major recycling exercise returning some 75 acres of land to agricultural use. (see Annex A for more information).
- 1967 Laying dense bases in thick layers was trialled on what is now the B4632 at Willicote bends – a comparison of the density achieved using two 75mm layers of 40 mm dense base and one 150 mm layer. The latter had a far superior density. Warwickshire always encouraged the use of thick layers thereafter.
- 1968 Airfield friction course (10 mm porous asphalt) – late 1960s and early 70s – although initially very successful and producing good quiet surfaces it proved to lack durability and was dropped. The cause of the poor durability is now better understood but other surfacing materials have taken its place. (HAPAS thin surfacings)
- 1974 Delugrip was the first of the proprietary thin surfacing materials which was developed at Birmingham University in conjunction with Dunlop. It was potentially a good surfacing material but never took off because of its cost.
- 1978 Medium temperature asphalt (55/10F) was first laid on the C43 outside Mallory Court Hotel and its use spread throughout the County. It then spread to the UK Midlands and beyond and became a British Standard Material. It is now included in EN 13108-4.
- 1982 Racked in, Double and Sandwich surface dressing – Warwickshire were early adopters of these techniques which, together with polymer modified binders, transformed the potential for long life surface dressing on all roads and levels of site difficulty.
- 1994 Some of the first trials of thin surfacing on non-trunk roads took place in Warwickshire in 1994 at the entrance to Tarmac Nuneaton quarry and is now in frequent use on appropriate sites.
- 2002 First trials of the reuse of clean sweepings of surface dressing chippings. This proved successful and has continued; 100,000 sq m were done in 2004. it was reported in 'Surveyor' in 2004.
- 2004 Use of Tarmac's Masterflex which is a thick single layer structural surface course with a sustainability benefit. Not only does it have good structural and ride qualities it also uses a polymer modified binder allowing it to flex in sympathy with underlying ground movements. This is now Ultiflex.
- 2009 Masterlayer is a lower texture version of Masterflex with some potential for crack bridging. This is now Ultilayer
- 2011 Masterpave D is a high performance surfacing with 6.5 % of high performance polymer modified binder. This is very tough and has been used successfully on heavily trafficked roundabouts – eg Birmingham Road Island across Warwick Bypass. This is now Ultipave D
- 2013 55/6-14F (Hybrid) is a replacement for 55/10F but uses very little of scarce 10 mm aggregate. (This material was suggested by Tarmac other suppliers may have similar materials with different names).

18.2 The trialling of new materials and techniques shall be encouraged but they must be formally and properly monitored by means of suitable tests and visual assessments. For surfacings one of the best technique is to take photographs from the same position at regular intervals.

Last amendment July 2015

19 Improving Sustainability

19.1 There are number of materials and processes used in the County which have very poor durability and/or sustainability compared to what is possible. Some of these are listed below and it is County policy to improve on the sustainability of these materials and processes.

19.2 Road marking materials – white and yellow lines. It is noticeable that the life of these materials is extremely variable. Some such as on C43 between Fosse Way and Harbury (probably 'Rainline') have been in place for many years (probably since 1999 when it was last surface dressed) and are still fairly good and very visible in the dark and wet whereas others seem to last a very short time and have poor visibility in the dark and wet. Comparative trials should be carried out to determine the most sustainable options.

19.3 The use of calcined bauxite merely for its colour has a very high environmental cost which is not balanced either by its durability or any engineering properties. Trials should be carried out to determine suitable contrasting aggregates from natural sources which can be used as 6 mm surface dressing to form the coloured patches. There are number of green, red, pink and light grey aggregates from UK sources which could prove suitable; see Appendix C to Chapter 10.

19.4 Many hand laid patching materials have poor durability – whether this is inherent in the materials or is a function of poor installation is a matter of conjecture. Trials should be carried out to determine whether better installation would improve the life of the patch, for example by removing material to a greater depth so that the patch is structurally adequate. Efforts should also be made to source more durable materials that are suitable for patching and that are tolerant of adverse conditions particularly for safety patching which must be carried out in any weather conditions.

19.5 Another area where early failure is endemic is the reinstatement around ironwork whether or not it has been reset. Trials should be carried out on potentially suitable materials and/or systems.

19.6 Although the previous source (Total) of surface dressing binder served the County well. There is some doubt about the binder used in the 2013 summer although it met specification requirements. There were many failed areas so it would be advantageous to have alternative sources trialled and approved to enable continued long life of this very sustainable process. One of the problems is that there is no specification for wet weather tolerance or early strength to resist power steering from new.

19.7 A new type of binder has recently undergone trials which uses a flux derived from plant materials. Traditional fluxes evaporated leaving behind a binder which gradually hardened. These new fluxes work by themselves polymerising which enables a fluid binder to be used which quickly becomes strong with no volatile organic compounds. They also have the advantage of being less weather susceptible than any previous type of binder.

19.8 With the advent of new manual handling regulations various new ideas for kerbs such as permanent plastic moulds or hollow concrete kerbs, each of which are filled with concrete on site, are being introduced. Pressed concrete kerbs are very durable products and have often been reused. The question arises, therefore, whether these new ideas are similarly durable and is there any scope for reuse or recycling. Trials should be carried out but until the cost comes down significantly there are no advantages, to date, over conventional concrete kerbs. Concrete kerbs are either reusable or recyclable whereas most of the alternatives are neither.

Last amendment

20 References and Bibliography

Table 20.1 gives the list of the supporting papers held by Network Management, Table 20.2 gives the list of direct references and Table 20.3 gives a bibliography of other documents and publications which give useful background

Table 20.1 Supporting papers

Number	Title
1	Binder grade in structural layers
2	Polished stone values
3	Effect of aggregate size on skidding resistance
4	Roughness and ride quality – effects on structural life
5	Noise – what affects it
6	Structural contribution of thin surfacings
7	Patching – causes and their investigation
8	Environmental assessment of maintenance works
9	HAPAS system
10	Capping layers and sub-bases – an assessment

Table 20.2 References

Author	Title and source
	Re-using surface dressing chippings. Surveyor 2004
ADEPT	*Selection of surfacing for highway pavements - Guidance for Local Authority Engineers*
ADEPT	SMDS annual workshop – meeting notes 2014
Anon	CDM regulations
BSI	BS 594987:2015 Asphalt for roads and other paved areas – Specification for transport, laying and compaction and type testing protocols
BSI	PD 6691:2015 Guidance on the use of BS EN 13108 Bituminous mixtures – Material specifications. (the references to the various parts of BS EN 13108 can be found in this document but it will be very unlikely for practitioners to need to use the standards themselves)
BSI	EN 13043:2002 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas (the 2013 edition was withdrawn)
BSI	BS EN 13242:2009 +A1:2013 Aggregates for unbound and hydraulically bound materials for use in civil engineering work and construction
BSI	PD 6682-2:2003 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas – Guidance on the use of BS EN 13043
BSI	BS 1377-2:1990; Method of test for soils for civil engineering purposes. Classification tests.

BSI	BS 5835-1:1980; recommendations for testing aggregates. Compactibility test for graded aggregates
BSI	BS 6677-1:1986. Clay and calcium silicate pavers for flexible pavements. Specification for pavers (withdrawn)
BSI	BS 6717-1:1993. Precast concrete paving blocks. Specification for paving blocks (withdrawn)
BSI	BS 7533 parts 1-12. Pavements constructed with clay, natural stone or concrete pavers. See BSI website for details of each of coverage of each part.
BSI	BS EN 12697-5:2009. Bituminous mixtures. Test methods for hot mix asphalt. Determination of maximum mix density
BSI	BS EN 1338:2003. Concrete paving blocks. Requirements and methods of test
BSI	BS EN 1344:2013. Clay pavers. Requirements and test methods
BSI	BS EN 12271:2006 Surface dressing – Requirements
BSI	BS EN 12273:2008 Slurry surfacing – Requirements
BSI	BS EN 12272-2:2003 Surface dressing – test methods – Part 2 Visual assessment of defects
BSI	BS EN 12274-8:2005 Slurry surfacing – test methods – Part 8 Visual assessment of defects
BSI	BS EN 14023:2010 Specification Framework for polymer modified binders
BSI	PD 6689:2009 Guidance on the use of BS EN 12271 and BS EN 12273; surface treatments
Catt C	An Alternative view of TRRL's Research into skidding resistance. Asphalt Technology no 33, July 1983
Catt C	Justification for general reduction of IL in 30 mph areas. For WCC SCRIM strategy 2011
CSS	ENG6-94; Pavement design manual; CSS 1994
CSS	Guidance note on skidding resistance; CSS, 2005
CSS	Code of Practice on Skid Resistance for Local Authority Roads. Background Research Report. CSS 2009
Department for Transport	Road casualties in Great Britain – Annual publication
Department for Transport	Local Transport Note 01/07 Traffic Calming
Department for Transport	Manual for Streets 2007
DfT/UK roads board	Best Practice Guidelines for the specification of thin surfacing and stone mastic asphalt 2005
Environment Agency	The use of treated asphalt waste containing coal tar in construction operations. Regulatory position statement 2012. www.environment-agency.gov.uk

HAPAS	Guidelines and certificates for high friction surfacing (SG1), inset and overband crack seals (SG2), thin surfacing (SG3), polymer modified binders (SG4) and permanent cold lay surfacing materials (SG8). See www.bbacerts.co.uk for more details
Highways Agency	IAN 73/06 rev 1. Design guidance for road pavement foundations (draft HD 25) 2009
Highways Agency	IAN 96/07 Rev 1 Guidance on implementing results of research on bridge deck waterproofing
Highways Agency	IAN 156/12 Revision of Aggregate Specification for Pavement Surfacing
Highways Agency	Design manual for Roads and Bridges – volume 7; Pavement Design and Maintenance; continually updated (Includes HD23 to HD 40)
Highways Agency	Specification for Highway works volume 1 – Specification; continually updated
Highways Agency	Specification for Highway works volume 2 – Notes for guidance; continually updated
Hosking R	Road Aggregates and skidding, TRL state of the art review/4; HMSO 1992
IHIE	Guidelines for motorcycling. Improving safety through engineering and integration. IHIE 2005
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Sustrans	Cycle Path Surface Options Technical Information Note No. 8
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TRL	Road note 42; 2008; Best Practice Guide for Durability of Asphalt
Vansteenkiste S O and A F P Verhassalt	Comparative study of rapid and sensitive screening methods for tar in recycled pavements. Road Materials and Pavement Design Volume 5; proceedings of first EATA conference Nottingham 2004
WCC	Road Safety Strategy
WCC	Skid Testing Strategy
WCC	Transport and Roads for Development: The Warwickshire Guide; 2001
WCC	Transport Asset Management Plan 2011
WCC	Village speed limit review

WCC	Warwickshire Highway Maintenance – Policy document
Waste and resources action programme (WRAP)	A66 Little Burdon to Newton Grange resurfacing. Case study into recycling tar bound base. WRAP undated (but post 2011) www.wrap.org.uk

Table 20.3 Bibliography

Author	**Title and source**
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Croney D and P Croney	The design and performance of road pavements; 2nd edition. McGraw Hill 1991
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Lilley A	A Handbook of segmental paving. E & FN Spon 1991
Nichols J C (editor)	Asphalt surfacings – A guide to asphalt surfacings and treatments used for the surface course of road pavements. E & FN Spon 1998
Thom N	Principles of pavement design. Thomas Telford 2008

*Although very old this is still one of best books for explaining how bituminous roads work

** This is a pan European review of latest research on the effects and movement of water in pavements

Annexes

A W150 and W75 sub-base

A1.1 The aim of this specification is to maximise the use of recycled materials and also use materials that are produced in quarries as part of their normal processes without unnecessary processing.

A1.2 The sub-base shall be known as W150 (D=125) or W75 (D=75) as appropriate depending on the maximum size of the aggregate permitted. The specification is now clause 890AR and is set out in Part 3.

NOTE: although the main sieve size is now 125 mm for W150 the designation has not been changed as the material is essentially the same and there will be no need to re-educate users and suppliers

NOTE: for explanation and definition of 'D' and 'd' see PD 6682-2

For recycled materials the simplest way of obtaining W75 is to set the crusher at about 90 mm and screen the crushed material on a 20 mm screen. The retained material will be acceptable as W75 and a thin layer of the fines (providing there is little or no soil or clay in the original material) can be used to regulate.

Notes on W75 and W150

A1.3 The first use in Warwickshire of open graded sub-bases was on Warwick Bypass which was built between 1965 and 1967. (It is possible that it was also used on Meriden bypass). Warwick bypass used crushed concrete from two World War 2 airfields; Honiley and Atherstone on Stour. The latter was just south of Stratford. About 80 acres (32 ha), mainly at Atherstone, were returned to agriculture. The concrete runways were put through a mobile crusher with jaws set at 4.5" (115 mm) and the resultant crushed material screened over a ¾" (20 mm) screen. The coarse material was placed first and the fine material used to regulate the surface to provide a sound platform for the rest of the construction. This material has performed well even where the sub-base had been fully waterlogged. The open texture of material ensured good particle interlock even when saturated thus preventing pumping of the fines and damage to the clay sub-grade.

A1.4 Following this early use it was found that the material grading used on Warwick Bypass was too coarse for strip widening and similar constrained sites and a smaller material following the same philosophy was developed which became W75 and as quarry plant increased in size it was convenient to increase the size of the larger material to 150 mm (and even larger material was used when reconstructing the M6).

A1.5 The precise grading is unimportant so materials that do not comply with the grading limits may well be suitable particularly if the non-compliance is on the coarse side provided it can be handled and placed where required. The important factor about these materials is that they have high to very high levels of permeability with k at least 10^{-2} m/sec in Darcy's law and for the coarsest ones k=1 m/sec approximately. The intention at all times was and is to use materials that the quarries produced with a minimum amount of energy, preferably as part of or a by-product of other production. This became more difficult over time as suppliers wished to know the precise specification against which they were supplying. The primary requirement is no longer the grading but the permeability which is much more important than the exact grading for the performance of the sub-base. The gradings that are in 890AR give a material deemed to comply with the permeability requirements.

A1.6 It is important to connect these materials to the drains in an efficient manner either by ensuring good connection to filter drains or by laying a separate drain in a chase on the low side which is connected to a drainage system at suitable intervals. Any upstands of impermeable materials must be prevented from forming as these would form a barrier to free drainage.

A1.7 Type 1 has gained credibility over the years as a 'strong' sub-base – this is only correct when it has been placed at optimum moisture content and compacted to something approaching its maximum density. It seems surprising, therefore, there is no requirement for it to be placed and compacted at optimum moisture content, which would also reduce its tendency to segregate. The open

graded Warwickshire sub-bases have over the years been shown to remain adequately ‘strong’ under any moisture regime. Recent research at Nottingham University has shown that open graded unbound materials are stiffer then well graded ones and hence better at load spreading. Another problem with type 1 is that it is never free draining as when it is compacted to a dense mass it has a measurable suction of about 200 mm; this is sufficient to draw water in from the sides of the sub-base across about 8m or two lanes when laid at 1 in 40 crossfall.

A1.8 Sub-bases and capping layers spread load and as such shear forces and potential tensile forces are generated. As unbound materials cannot accept tensile forces the limit is reached when any compressive stresses induced in the material by overlying layers and the traffic load have been overcome. With type 1 positive pore water pressures can be generated when it is saturated and this destroys any ability to spread load. Type 1, therefore is intolerant of inadequacies in construction and maintenance. Conversely the open graded WCC sub-base do not suffer from pore water pressures and aggregate interlock remains good even under water. Therefore they are fairly tolerant of poorer drainage maintenance.

Last amendment May 2015

B Minimum Polished Stone Value of Chippings

The minimum polished stone values given in the table are for 10 mm aggregate in surface dressing, thin surfacing and, where the speed limit is 30 mph or less for 55/10F asphalt.

The minimum PSVs given in the table shall be **increased by 5** where 14 mm or 20 mm aggregate is used in any surfacing and where 55/10F asphalt is used on roads with 40 mph or higher speed limits.

NOTE: 65 will be increased to 68+

The minimum PSVs given in the table shall be **decreased by 5** where 6 mm aggregate is used in the any surfacing. (For this purpose only 68+ is assumed to be 70)

Site group	Site Description	Minimum PSV required for given IL, traffic level and type of site							
		Risk rating	IL	Traffic (cv/lane/day) at design life					
				0-20	21-100	101-250	251-500	501-750	751-1000
1	Dual carriageways (risk rating 2) and single carriageways (risk rating 3) where traffic is generally free-flowing on a relatively straight line.	**2**	**0.35**	50	50	50	50	50	55
		3	**0.40**	50	50	50	50	50	55
		4	**0.45**	55	55	55	55	55	60
3	Approaches to major and minor junctions or other hazards on all-purpose dual carriageways and single carriageways where frequent or sudden braking occurs but in a generally straight line, including pedestrian crossings and mini-roundabouts	**4**	**0.45**	55	55	55	60	60	65
		5	**0.50**	55	55	60	65	65	68+(70)
		6	**0.55**	50	60	65	68+(70)	68+(70)	68+(70)
4	Gradients (>5%) longer than 50 m	**4**	**0.45**	55	55	55	55	55	60
		5	**0.50**	55	55	60	65	65	68+(70)
		6	**0.55**	60	60	65	68+(70)	68+(70)	68+(70)
5	Bends on all types of road (<500 m radius note 1); roundabout circulation areas except mini roundabouts; approaches to hazards that require combined braking and cornering.	**4**	**0.45**	55	60	60	60	65	65
		5	**0.50**	60	60	65	65	68+(70)	68+(70)
		6	**0.55**	65	65	68+(70)	68+(70)	HFS(75)	HFS(75)

Notes:
1. Shaded lines are the default risk rating/Investigatory levels for that group **except** that for bends with a radius between 250 and 500 m when the default risk rating is 4 and the required PSV is in highlighted text
2. Where '68+' material is listed in this Table, none of the three most recent results from consecutive tests relating to the aggregate to be supplied shall fall below 68.
3. HFS means that high friction surfacings complying with MCHW 1 Clause 924 will be required.
4. Investigatory Level (IL) is defined in Chapter 3 of HD 28 (DMRB 7.3.1)

Last amendment May 2015

C Non-standard Hot Rolled Asphalts

C1 These HRA types have a long history of use in Warwickshire. The following types are shown:

1. Hot rolled asphalt 55/6F surf 100/150 (used for machine laid surfacing to footways and cycleways)
2. Hot rolled asphalt 45/6F surf 160/220 and Hot rolled asphalt 45/10F surf 160/220 (used for hand laying). These two specifications were developed in Warwickshire specifically for hand laying and were taken up by the Highways Agency in HD 39, the advice note for footways, where the pre EN 13108 specifications may be found.

C2 The specification 55% Stone Hot Rolled Asphalt Surface Course (for machine laying) is now 972AR in Part 3

C3 The specification for 45% Stone Content Hot Asphalt Surface Course (for hand laying) is now clause 970AR in part 3.

D Foreseeable changes

There are a few changes that can be expected in the near future or have just taken place.

- The 900 series of the Specification for Highway works has been sent into the EU approval system. It can be expected to emerge before the end of 2015. It modifies a limited number of clauses but clause 942 is one of them.
- A revised HD 28 has also been entered into the same procedure.
- There is a possible change from (sand)* patch texture to machine measured texture being the default method – this is still being debated
- A revised HD37 has been drafted but is not likely to be published for some time if at all.
- The major research project on aggregate size and skidding mentioned in the 2009 edition has reported [Roe and Dunford 2012] and has shown the WCC interpretation is conservative particularly for negatively textured materials.
- The Highways Agency is now Highways England, an arm's length government company. It will continue to maintain the documents of specification and advice that they currently do.
- There are advanced discussions in Europe on the replacement of PSV with Friction after Polishing (FAP); better known as the Wehner Schulze Test (for some of the disadvantages of FAP see code of practice on Skid Resistance for Local Authority Roads. Project 41 Background Research Report [CSS 2009])

* the reference test now uses glass beads, sand is often used except in cases of doubt.

E Abbreviations and Acronyms

The following acronyms and abbreviations have been used in this strategy.

Acronym	Meaning
AAV	Aggregate Abrasion Value
BBA	British Board of Agrément
BS	British Standard
CBR	California Bearing Ratio (a measurement of soil bearing capacity)
CDM	Construction, Design and Management regulations
CSS	County Surveyors Society
Cv/l/d	Commercial vehicles per lane per day
dB(A)	Decibels, A weighted
DBM	Dense Bitumen Macadam
DfT	Department for Transport
DMRB	Design Manual for Roads and Bridges
EN	Euro norm (European Standard)
FAP	Friction after Polishing (proposed replacement for PSV test)
GPa	GigaPascals
HA	Highways Agency
HAPAS	Highway Authority Product Assessment Scheme
HAUC	Highway Authority and Undertakers Committee
HD	Highways Agency Advice Note
HDM	Heavy duty macadam
HRA	Hot Rolled Asphalt
IL	Investigation level
ISO	International Standards Organisation
ITSM	Indirect tensile stiffness modulus
LTP	Local Transport Plan
msa	Million standard axles
MSSC	Mean summer SCRIM coefficient
MPA	Mineral Products Association (was QPA)
MTA	Medium Temperature Asphalt (historical name for 55/10 HRA with 125 pen binder
NG	Notes for Guidance (in volume 2 of SHW)
PANDEF	Standard method of reporting Deflectograph data (nearly obsolete)
PI	Plasticity Index
PM10	A measurement of respirable dust (less than 10 μm diameter)
PPV	Polished Paver Value
prEN	Draft (provisional) European Standard
PSV	Polished stone value
QPA	Quarry Products Association (now MPA)
SATS	Saturated ageing tensile stiffness (a test for water sensitivity for bituminous materials)
SCANNER	Traffic speed survey method
SCRIM	Sideway-force Coefficient Routine Investigation Machine
SHW	Specification for Highway Works
TRL	Transport Research Laboratory
TRRL	Transport and Road Research Laboratory (predecessor name of TRL)
WCC	Warwickshire County Council

Part 3 Specification clauses and example 7/x appendices

890AR Warwickshire sub-bases

1 The lower sub-base is designated W150 or W75 as appropriate depending on the maximum size of the aggregate permitted

2 The lower sub-base shall consist of crushed rock, crushed slag, crushed concrete or crushed recycled aggregates. The permeability coefficient shall be not less than 10^{-1} m/s for D = 150 mm and not less than 10^{-2} m/s for D = 80 mm. Materials complying with the grading limits given in Table 890/1 are deemed to comply with this requirement.

3 Gradings outside the limits given in the table may be used provided that the permeability complies with the requirements of this clause as demonstrated using the test method for permeability in HA 41/90 A Permeameter for road drainage layers.

4 The material passing the 425 um BS sieve, when tested in accordance with BS 1377 shall be non-plastic.

5 The aggregates used shall conform to clause 801 of the Specification for Highway Works for Type 1 unbound mixtures except that proven materials, eg ironstone, are acceptable as are crushed and screened recycled materials. If crushed concrete or crushed recycled aggregates are to be used, screening shall ensure that:

i. the maximum content of other materials (Class X - including wood, plastic and metal) is 1% by mass;
ii. and 100% of other materials (Class X - including wood, plastic and metal) passes through the 31.5mm sieve.

6 The material shall be laid and compacted in accordance with clause 802 of the Specification for Highway Works with the following exceptions:

i. Layer thickness may be up to 4 times the upper aggregate size (D) – ie 300 mm for W75 and 600 mm for W150. The minimum layer thickness shall be 150 mm and 300 mm respectively.
ii. Where the materials comply with the limits given in Table 1 compaction by means of the placing and spreading plant is usually sufficient particularly when using ironstone or Cotswold stone which are prone to breakdown.
iii. Segregation shall be kept to a minimum.

Table 890/1 Sub-base

	W75	**W150**
Sieve size	**% passing**	**% passing**
300 mm		100
125 mm	100	60-85 [D]
75 mm	0-100 [D]	
37.5 mm	0-50	0-25
10mm	0-20	0-8
0.6 mm	0-5	
0.063 mm	0-2	0-1

924SR High Friction Surfaces

1 High friction surfacing systems shall have current HAPAS Roads and Bridges Certificates.

2 A high friction surfacing system with a current HAPAS Roads and Bridges Certificate shall only be installed by a Contractor approved by HAPAS and the Certificate Holder as an Approved Installer for that system.

3 The high friction surfacing system HAPAS Type Classification required for each location shall be as specified in Appendix 7/23

Aggregate

4 Aggregate used in high friction surfacing systems shall have a minimum declared PSV category specified in Appendix 7/1 in accordance with BS EN 13043, clause 4.2.3. The resistance to abrasion of coarse aggregate shall have a maximum AAV specified in Appendix 7/1 in accordance with BS EN 13043, clause 4.2.4. The Contractor shall provide, before work commences, test certificates, issued by an appropriate organisation accredited in accordance with sub-Clauses 105.3 and 105.4 for those tests, not more than six months previously, showing conformity with the requirements

Installation and Quality Control Procedures

5 The installation and quality control procedures shall be in accordance with the HAPAS Certificate for each system and the current method statement agreed by the HAPAS certificate issuer. The results of all quality control checks carried out on site by the Contractor and quality assurance information compiled in accordance with the requirements of the Certificate, including results from surveillance visits, shall be made available to the Overseeing Organisation on request.

System Coverage

6 For each location where high friction surfacing is applied, the total quantities of each system component used, the measured area of the surface treated and the calculated coverage rate in kg/m^2 shall be reported to Warwickshire County Council within three days of completion at that location. For systems in which aggregate is broadcast over a film of binder applied to the surface, the calculated coverage rate shall be that of the binder film and shall not include the mass of the aggregate

Performance requirements

7 The performance required from the material as laid is set out in Appendix 7/23 using the tests described in the same appendix.

970AR 45% Stone Content Hot Rolled Asphalt Surface Course (for hand laying)

1. 45% stone content hot rolled asphalt surface course shall comply with sub-Clauses 2, 3, 4, 5 and 6 of this Clause, and the requirements of Appendix 7/1 or Appendix 11/1 as appropriate. It shall also comply with 973AR for compaction.

2. Materials shall comply with BS EN 13108-4, shall have the following target gradings and binder content, and shall be recipe type F.

BS Test Sieve	Target % by mass of total aggregate passing BS test sieve		
Designation (See Appendix 7/1 or Appendix 11/1	45/6F	45/10F	45/14F
20mm	-	-	100
14mm	-	100	95-100
10mm	100	95-100	52-72
6.3mm	90-100	-	-
2mm	51	51	51
0.5mm	37-53	37-53	37-53
0.25mm	13-38	13-38	13-38
0.063mm	7	7	7
Minimum target binder content % by mass	6.3	6.3	6.3

3. In carriageways the coarse aggregate shall be crushed rock with a minimum polished stone value of 55 unless otherwise stated in Appendix 7/1.

4. In cycleways, the coarse aggregate shall be crushed rock with a minimum polished stone value of 50, unless otherwise stated in Appendix 11/1.

5. In footways, the coarse aggregate shall be crushed rock with a minimum polished stone value of 50, unless otherwise stated in Appendix 11/1.

6. The binder shall be 160/220 grade bitumen and the temperature shall not exceed 160°C at any time.

971AR Not Used

972AR 55% Stone Content Hot Rolled Asphalt Surface Course (for machine laying)

1. 55% stone content hot rolled asphalt surface course shall comply with sub-Clauses 2, 3, 4 and 5 of this Clause, and the requirements of Appendix 7/1 or 11/1 as appropriate.

2. Materials of designation 55/10F surf and 55/14F surf shall comply with PD 6691 Table C2A columns 6 and 12 respectively. 55/6F surf shall comply with the target grading and binder content in the table below.

BS Test Sieve	Target % by mass of total aggregate passing BS test sieve
Designation	55/6F
10mm	100
6.3mm	90-100
2mm	41
0.5mm	29-43
0.25mm	9-31
0.063mm	6
Minimum target binder content % by mass	5.5

3. In carriageways, the coarse aggregate shall be crushed rock with a minimum polished stone value of 55, unless otherwise stated in Appendix 7/1.

4. In cycleways, the coarse aggregate shall be crushed rock with a minimum polished stone value of 50, unless otherwise stated in Appendix 11/1.

5. The binder shall be 100/150 grade bitumen.

6 Alternative gradings may be used for 55/10F provided it appears visually similar and subject to a site laying trial demonstrating that the appearance, compaction level and typical surface texture are similar to a normal 55/10F from the same source. A slightly lower binder content may be needed.

7 Compaction shall comply with clause 973AR.

8 Bond strength shall comply with clause 975AR

973AR Compaction Requirements

1. The adequacy of compaction of bituminous materials used in the carriageway shall be determined by the Overseeing Organisation from the attained air void content of the laid material in the following way:

i. Compliance shall be judged from the determination of air voids for areas of 1000 m² or from the area laid in one day when this is less, or from multiple areas to the nearest 1000 m² on large sites. Three 100 mm nominal diameter cores pairs shall be taken from each area. At least two of the core pairs shall be from the wheel track zones of the completed carriageway. The wheel track zones are defined in BS 594987 Clause 9.5.1.3; and

ii. In situ air voids shall be determined in accordance with BS 594987 clause 9.5.1.3.

2. Where these requirements for the air voids are not met the Contractor shall determine the full extent of the area of the defective material to the satisfaction of the Overseeing Organisation. The full depth and width of the defective material, minimum 15 m long and the full width of the paver, shall be removed and replaced with fresh material laid and compacted to this Specification.

3. Additionally, every 500 lin metres of joint (or more frequently where there is doubt about compaction) a pair of 100 mm nominal diameter cores shall be taken each side of joint located in accordance with Clause 903.24.

4. An indirect density meter may be used, with the prior approval of Overseeing Organisation, to reduce the amount of coring required, provided that sufficient information is available to correlate the readings against core results. For proper correlation of the density meter, at least 18 No. cores shall be taken for each material/supplier combination from the specific site for which the correlation shall apply, having been tested prior to coring with the actual density meter for which the correlation data is required. In cases of disputes over compliance with compaction specifications, the core density method shall be used.

5 The Contractor shall achieve an air void content conforming with the limits set out in the table below.

Table 9/71 – Compaction Requirements (Air Voids)

Materials	Mean of 6 cores		Mean of any pair	
	Min %	Max %	Min %	Max %
Dense base and binder course mixtures to clause 906	2	6	1	8
All hot rolled asphalt materials except 45/10F to clause 970AR (any layer)	2	6	1	7
45/10F to clause 970AR	2	8	1	9
SMA binder/regulating course to Clause 937	In accordance with Clause 937			
All stone mastic asphalt surface courses	2	6	1	7
Bridge deck surfacing	In accordance with IAN 96/07			

974AR Retread Process

1 Retread shall be carried out in accordance BS434-2 2006 and the contractor's operation procedures. As soon as possible after carrying out the process a surface course as stated in Appendix 7/8.

976 AR Stone Mastic Asphalt (SMA) surface course

Supersedes clause 942

1 Stone Mastic Asphalt (SMA) surface course shall be manufactured in accordance with BS EN 13108-5 and PD6691 and laid in accordance with BS 594987 to achieve the compaction requirements of clause 973AR and the strength of bond with the underlying layer in accordance with 975AR.

2 The grading and binder content limits shall be chosen by the laying contractor to ensure that the material can be laid to meet the requirements of this specification.

3 Aggregates shall comply with the requirements of clause 901 and detailed requirements set out in Appendix 7/1.

4 Binders shall be polymer modified and conform to the requirements set out in Appendix 7/1. The binder shall be either 65/105-45, 75/130 -45 or 75/130-75 in accordance with BS EN 14023-2010. The Fraass breaking point shall be ≤-12 for the first 2 binders and ≤-20 for the latter. The binder to be used shall be as stated in Appendix 7/1. Binder data for these binders shall be as stated in Appendix 7/1.

977AR Bond Between Asphalt Layers

1 The requirements of this clause are additional to and do not replace clause 920

2 The testing of bond between layers shall be carried out using one of the following methods:

i. When cores are taken the bottom of any layer being tested for voids shall be well bonded to underlying asphalt and a saw must be needed to separate the layers.

ii. Torque bond test in accordance with BBA/HAPAS method for thin surfacing. The minimum bond strength shall be ≥200 kPa.

3 Bond application: On class D roads the bond coat shall be sprayed not earlier than 24 hours before laying commences (with careful planning this enables two days laying to be sprayed on 1 visit of the spray tanker). However on class C or higher class roads spraying shall only take place after the road has been closed to public traffic.

4 the rate of spread and the binder data required are set out in Appendix 7/4

Last amendment July 2015

APPENDIX 7/1: PERMITTED PAVEMENT OPTIONS

The various tables set out in Appendix 7/1 cover all the probable options needed for maintenance but for specific works, particularly for Design Services work the appropriate options only may be inserted into the documentation. Where 'xx' is indicated in the tables the compiler should insert the relevant requirements.

A Hot rolled asphalt and chips

At the discretion of Warwickshire County Council the surface course may be permitted to be:

The specification to be used shall be: HRA 30/14F 40/60 (or 100/150) rec Schedule 1A as specified in BS PD 6691 Annex C. The chippings shall conform to BS PD 6691 table C5 20 mm nominal size and shall be spread at a rate of 70% shoulder to shoulder. Texture depth must not be specified. The normal binder would be 40/60 pen but for lighter trafficked roads where rutting is unlikely to be a problem 100/150pen may be used with particular advantage in cooler conditions.

The relevant information should be given on a site by site basis.

B Flexible Construction – 55% Stone Content Hot Rolled Asphalt (Clause 972AR) or approved equivalent

1. Location: All Carriageways

2. Grid for checking surface levels of pavement courses (Clause 702.4):

   (i) Open Carriageway-Longitudinal Dimension = 10m Transverse Dimension = 2m

   (ii) Junctions Longitudinal Dimension = 5m Transverse Dimension = 2m

3. Surface regularity (Clause 702.7): Category A Roads

4. The Compaction Assessment shall be as specified in Clause 973AR (Air Voids Test). Note that the equivalence requirements of sub-Clause 903.17 do not apply.

5. Regulating courses (Clause 907) shall be in accordance with WCC HCD No B705.2.

6. Only materials which comprise at least 80% bituminous planings shall be permitted for use as upper sub-base under the Type 2 Unbound Mixtures category.

Pavement Layer	**Clause**	**Material**	**Grade of Binder**	**Thickness (mm)**	**Special Requirements**
Surface Course	972AR	55% Stone Content Hot Rolled Asphalt	100/150	40 (note 1)	Designation 55/10F surf PSV of coarse aggregate [xx]
Binder Course	906	Dense Asphalt Concrete	100/150	60 (note 2)	AC20 dense bin Coarse aggregate: crushed rock or slag
Base	906	Dense Asphalt Concrete	100/150	[xx]	AC32 dense base Coarse aggregate: crushed rock or slag
Upper Sub-base	803, 804 or 805	Type 1, Type 2 (see paragraph 6 above) or Type 3 (open graded) Unbound Mixtures	-	150	
Lower Sub-base	890AR	W150 or W75	-	[xx]	
TOTAL PAVEMENT THICKNESS				**[xx]**	

Note 1: 40 mm is the normal and preferred thickness; thicker layers may be more suitable where an overlay is being used of variable thickness. Insert alternatives as appropriate.

Note 2: 60 mm is the normal and preferred thickness; thicker layers may be more suitable where an overlay is being used of variable thickness. Insert alternatives as appropriate. If a thinner layer is necessary then an alternative regulating material should be specified.

C Flexible Construction – Stone Mastic Asphalt Surface Course (Clause 976AR)

Stone Mastic Asphalt Surface Course

1. Location: All Carriageways

2. Grid for checking surface levels of pavement courses (Clause 702.4):

   (i) Open Carriageway-Longitudinal Dimension = 10m Transverse Dimension = 2m

   (ii) Junctions-Longitudinal Dimension = 5m Transverse Dimension = 2m

3. Surface regularity (Clause 702.7): Category A Roads

4. The Compaction Assessment shall be as specified in Clause 973AR (Air Voids Test). Note that the equivalence requirements of sub-Clause 903.17 do not apply.

5. Regulating courses (Clause 907) shall be in accordance with WCC HCD No B705.2.

6. Only materials which comprise at least 80% bituminous planings shall be permitted for use as upper sub-base under the Type 2 Unbound Mixtures category.

Pavement Layer	Clause	Material	Grade of Binder	Thickness (mm)	Special Requirements
Surface Course	976AR	10 mm SMA surface course	[xx] (note 1)	40 (note 2)	PSV of coarse aggregate [xx]
Binder Course	906	Dense Asphalt Concrete	100/150	60 (note 3)	AC20 dense bin Coarse aggregate: crushed rock or slag
Base	906	Dense Asphalt Concrete	100/150	[xx]	AC32 dense base Coarse aggregate: crushed rock or slag
Upper Sub-base	803, 804 or 805	Type 1, Type 2 (see note 6 above) or Type 3 (open graded) Unbound Mixtures	-	150	
Lower Sub-base	890AR	W150 or W75	-	[xx]	
TOTAL PAVEMENT THICKNESS				**[xx]**	

Note 1: see section D of this appendix for options on grades

Note 2: 40 mm is the normal and preferred thickness; thicker layers may be more suitable where an overlay is being used of variable thickness. Insert alternatives as appropriate.

Note 3: 60 mm is the normal and preferred thickness; thicker layers may be more suitable where an overlay is being used of variable thickness. Insert alternatives as appropriate. If a thinner layer is necessary then an alternative regulating material should be specified.

D1 Overlay options for roads carrying 100 cv/l/d or more with a speed limit 50 mph or above

The Compaction Assessment shall be as specified in Clause 973AR (Air Voids Test). Note that the equivalence requirements of sub-Clause 903.17 do not apply.

The specifier must state if the high performance binder 75/130-75 is required. (see Section D of this Appendix)

Thickness (mm) and type			
Overlay total	Clause 976AR material	Binder course	Base
25 - 30	1 layer of 0/6	0	0
35-50	1 layer of 0/10	0	0
55-70	1 layer of 0/10 or 0/14	0	0
80	40 mm 0/10	40 of SMA to clause 937 (or 976AR)	
90	40 mm 0/10	50 of SMA to clause 937 (or 976AR)	
100	40 mm 0/10	60 of AC 20 dense bin to clause 906	
110	40 mm 0/10	70 of AC 20 dense bin to clause 906	
120	40 mm 0/10	80 of AC 20 dense bin to clause 906	
130	40 mm 0/10	90 of AC 20 dense bin to clause 906	
140	40 mm 0/10	100 of AC 20 dense bin to clause 906	
150	40 mm 0/10	110 of AC 20 dense bin to clause 906	
160	40 mm 0/10	60 of AC 20 dense bin to clause 906	60 of AC 32 dense base to clause 906
170	40 mm 0/10	60 of AC 20 dense bin to clause 906	70 of AC 32 dense base to clause 906
180	40 mm 0/10	60 of AC 20 dense bin to clause 906	80 of AC 32 dense base to clause 906
190	40 mm 0/10	60 of AC 20 dense bin to clause 906	90 of AC 32 dense base to clause 906
200	40 mm 0/10	60 of AC 20 dense bin to clause 906	100 of AC 32 dense base to clause 906

Clause 906 materials may be replaced with clause 929 materials where it is more economical to do so.

SMA to clause 976AR would normally use either 65/105-45 or 75/130-45 to BS EN 14023 depending on binder supplier. The choice of 75/130-75 to BS EN 14023 binder would only be required if there are special problems with the underlying structure.

D2 Overlay options for roads carrying less than 100 cv/l/d and all roads with speed limit 40 mph or below

The Compaction Assessment shall be as specified in Clause 973AR (Air Voids Test). Note that the equivalence requirements of sub-Clause 903.17 do not apply.

Thickness (mm) and type			
Overlay total	**55/10F HRA or equivalent**	**Binder course**	**Base**
40-70	Single layer	0	0
80	40	40 of AC 20 dense bin to clause 906	
90	40	50 of AC 20 dense bin to clause 906	
100	40	60 of AC 20 dense bin to clause 906	
110	40	70 of AC 20 dense bin to clause 906	
120	40	80 of AC 20 dense bin to clause 906	
130	40	90 of AC 20 dense bin to clause 906	
140	40	100 of AC 20 dense bin to clause 906	
150	40	110 of AC 20 dense bin to clause 906	
160	40	60 of AC 20 dense bin to clause 906	60 of AC 32 dense base to clause 906
170	40	60 of AC 20 dense bin to clause 906	70 of AC 32 dense base to clause 906
180	40	60 of AC 20 dense bin to clause 906	80 of AC 32 dense base to clause 906
190	40	60 of AC 20 dense bin to clause 906	90 of AC 32 dense base to clause 906
200	40	60 of AC 20 dense bin to clause 906	100 of AC 32 dense base to clause 906

HAPAS surface course systems: information to be provided by the contractor

Note to contractor: complete one sheet per system of variant of system as examples of systems that will be used.

The Contractor shall provide the following information with his tender:

1. When a HAPAS surface course is proposed a copy of the HAPAS Roads and Bridges Certificate or Certificates for the thin surface course system or systems that are proposed for use in the works, together with a copy of the Installation Method Statement associated with each Certificate*]*.

2. For any Certificate that covers several variants of one thin surface course system, the proposed variant or variants of the system to be used in the Works [variants of a system occur from any option that results in different values being reported on the Certificate for one or more properties, and could involve changes in nominal maximum aggregate size, aggregate type, aggregate grading, binder type, binder content, fibres or other additives, type and rate of spread of bond coat].

3. Prior to first use the proposed component materials to be used in the thin surface course system and their proportions for each proposed system.

4. Prior to first use the source or sources of coarse aggregate together with statement of properties including polished stone value, ten per cent fines value, aggregate abrasion value and flakiness index.

5. Only HAPAS materials that meet 973AR compaction requirements and 975AR for bond strength are permitted.

D3 Structural overlays with single materials

On lightly trafficked roads the following structural overlays using single materials are used.

The Compaction Assessment shall be as specified in Clause 973AR (Air Voids Test). Note that the equivalence requirements of sub-Clause 903.17 do not apply.

Special structural overlays		
Material	Thickness limitations	Notes
AC 20 dense bin to clause 906 with additional 0.5 % bitumen. The minimum PSV shall be 55	60 – 100 mm	Usually has a 6 mm surface dressing in one of the two following years
SMA 20 surface course with low polymer modified binder	60 – 100 mm	Gritting is permitted but not required
HRA 55/14F	60 - 100 mm	

E Binders for Stone Mastic Asphalt

Only polymer modified binders shall be used. The binder shall be chosen from the following two options: low level of polymer modification or high level of polymer modification

A Low level shall conform to the following requirements:

BS EN 14023-2010: 65/105-45 or 75/130-45 (these two options shall always be given as it will depend on which binder supplier the mixed material supplier uses)

B High level shall conform to the following requirements

BS EN 14023-2010: 75/130-75

This option shall only be chosen when there are specific problems with the road structure to be overcome.

F BINDER DATA REQUIREMENTS

The following data shall be provided to Warwickshire County Council for modified binders as required in sub-Clauses 976.4AR. The data should not be more than 12 months old. The table gives the information that is required.

Manufacturer of Binder:	Product name:		
Binder type:	Batch no:		
Binder source:			
Softening point difference in storage stability test			
	Supplied Binder	**Aged binder**	**Recovered Binder**
Test	As supplied to site	Recovered in accordance with Clause 955	Aged in accordance with Clause 955 for 24 hour total or PAV85 to BS EN 14769:2012
Penetration at 25°C 0,1 mm (100g and 5 secs)			
Penetration at 5°C 0,1 mm (200g and 60 secs)			
Vialit pendulum cohesion BS EN 13588 maximum peak value J/cm^2	#	#	#
Summary ageing profile or provide full graph as shown in clause 955	#	#	#
Fraass brittle point			
Temperature for 300MPa stiffness in bending beam rheometer test			

Graphical output required

APPENDIX 7/2: EXCAVATION AND REINSTATEMENT OF EXISTING SURFACES

1. The locations of trenches, pits etc which require to be excavated in existing paved surfaces in order to carry out the works are shown on Drawing Nos. [insert nos].

2. The details of excavation and reinstatement of trenches are shown on WCC HCD No K701.1.

3. The locations of existing paved areas which are to be trimmed, regulated and reinstated to match levels where new and existing pavements abut are shown on Drawing Nos. [insert nos].

4. The details of trimming, regulating and reinstatement to match levels where new and existing pavements abut are shown on WCC HCD Nos. B705.1 and B705.2.

5. Refer to Appendix 7/9 for details of cold-milling.

APPENDIX 7/3: PERFORMANCE SURFACE DRESSING

SHEET 1: Information to be provided by the compiler

For footways the compiler need not specify all of the requirements and should use judgement and experience to determine which to omit.

1 Location *[922.1 - eg road number, name, OS grid reference of start and finish, lane]*

2 Limitations on binder cohesivity *[922.6 - minimum peak]*

3 Minimum declared PSV of chippings *[922.8]*

4 Maximum AAV of chippings *[922.8]*

5 Special traffic control requirements *[speed limit when first opened and minimum period of control 922.2]*

6 Class of spraybar accuracy required *[922.7]*

7 Class of chipping spreader required *[922.9]*

8 Class for tolerance of designed rate of spread of binder *[922.7]*

9 Class for tolerance of designed rate of spread of chippings *[922.9]*

10 Guarantee period *[922.3, normally 1 year]*

11 Traffic count *[922.1 - total and commercial vehicle count required for each lane]*

12 Traffic speed, 85 percentile *[922.2]*

13 Category of site *[922.1 - letter category from HD 36 (DMRB 7.5.1)]*

14 Description of existing surface *[922.1 and 922.4 - Macrotexture, existing defects, variability, etc.]*

15 Areas where horizontal road marking need to be removed prior to surface dressing**.**

16 Road hardness *[922.1, (normally the contractors responsibility) if he needs it for his design method]*

17 System of Surface Dressing permitted *[922.1 and 922.4 - for example: any, not single, racked-in, double or multiple-layered when tyre-road noise emission to be minimised]*

18 Minimum macrotexture depth at end of guarantee period *[922.19 (not normally specified)]*

19 Maximum macrotexture depth after 4 weeks trafficking *[922.19 - only required where noise is a problem, normally 3 mm macrotexture depth]*

20 Maximum percentage decrease in macrotexture between 12 months and 24 months after start of trafficking *[922.2 and 922.19 – not normally specified on 1 year guarantee period contracts]*

21 Frequency of testing *[922.14, NG 922.22]*

22 Category of fatting up, tracking and bleeding (% Area - P_1) acceptable *[922.20]*

23 Category of scabbing and tearing (% area affected - P_2), acceptable *[922.20]-*

24 Category of fretting (% chipping loss – P_3) *[922.20]*

25 Category of streaking (Length of streaking – P_4) *[922.20]*

26 Special restrictions *[922.13, 922.15 and 922 .16 - for example: maximum road surface temperature at which working permitted is 40ºC]*

[Note to compiler: If a number of sites are involved then it would be convenient to set out the above data in tabular form]

The table below shows the standards requirements for many of the above parameters for the main contract in Warwickshire. If any site requires different values then they must be listed separately in the project brief or task order.

Table 7/2.1 Summary of surface dressing requirements

	Road Type							
	Class A	Class A	Class B	Class B	Class C	Class D	Class D	Parking and untrafficked
Parameter	High stress	Other	High stress	Other		Rural	Urban	(note 1)
Minimum binder Cohesion	1.4 J/cm^2	1.2 J/cm^2 (note 2)	1.2 J/cm^2	1.2 J/cm^2 (note 2)	1.2 J/cm^2 (note 2)	1.2 J/cm^2 (note 2)	1.2 J/cm^2 (note 2)	1.2 J/cm^2 (note 2)
Rate of spread of binder tolerance	3	3	2	2	1	1	1	1
Binder coefficient of variation cv	2	2	1	1	1	1	1	1
Rate of spread of chippings tolerance	3	3	2	2	1	1	1	1
Chipping coefficient of variation cv	2	2	1	1	1	1	1	1
P1 fatting etc	3	3	2	2	2	2	2	2
P2 scabbing etc	3	3	2	2	2	2	2	2
P3 fretting etc	3	3	2	2	1	1	1	1
P4 streaking etc	3	3	2	2	2	1	1	1
Skidding resistance	No requirement							
Noise generation	No requirement							
Binder aging	To be reported		No requirement					
PSV	In accordance with Annex B of WCC Road Construction Strategy 2015. PSV for each site to be listed in the project brief or task order							
Macrotexture	No requirement							

Note 1: includes defined parking areas on urban streets and hatched areas at junctions.

Note 2: where a binder claims to have a cohesion of 1.0 J/cm^2 (intermediate grade) but normally and consistently meet the premium grade requirement of 1.2 J/cm^2 it may be approved for use subject to a demonstration.

Note on cohesion: previously the cohesion level was given in the form of classes but the relevant EN is being revised and the class descriptions are likely to change. However the cohesion levels are not hence the more complicated requirement using actual values.

SHEET 2: Information to be provided by the Contractor

The Contractor shall provide the following information with his tender:

1 A copy of BS EN ISO 9001 certificate showing at least the name of the Company, the name of the certification body and the reference number and date of the certificate. A copy of the relevant part of the company Quality Assurance (QA) document showing the appropriate scope and limitations of the certification including the requirements of Appendix A of BS EN 12271. The Service Manager will wish to inspect all or any of the company's QA documentation as part of the Service Manager's assessment system and may wish to satisfy itself on the nature of the QA systems of the company's/sub-contractor's material suppliers. *[922.2]*

2 Proposed binders together with their data sheets, product identification data and cohesivity data as specified. *[922.5 and 922.6] [Note to compiler: A suitable Sheet for the provision of binder data is given attached to this Appendix, other layouts are permitted but all the required data should be supplied]*

A copy of the binder data shall be sent to the Service Manager at least 2 weeks prior to first use.

3 Proposed source or sources of chippings together with statement of properties including target grading, target flakiness, CE mark values of PSV and AAV. *[922.8]*

4 A method statement for each Task Order or group of similar Task Orders showing how it is proposed to carry out the works in conformance with the Service Information. *[The Contractor will be expected to commit enough resources to carry out the proposed design in one single continuous pass, for example, if a double dressing is proposed on a heavily trafficked road then 2 sprayers, 2 chip spreaders, 2 rollers and 2 sweepers will be a minimum requirement. The type of plant, age and number should be detailed for example 2 computer controlled sprayers three years old]*.

5 Proposals for traffic control and aftercare for each site, and reaction times for carrying out remedial measures, sweeping and site visits with the Overseeing Organisation. *[922.12, 922.15, 922.16, 922.17]*

6 Contingency plans in the event of any breakdown of plant or failure of the dressing and provision for dusting. *[922.16]*

7 A copy of the CE certificate and a TAIT certificate complying with BS EN 12271 for each type of surface dressing proposed *[922.4]*

8 A statement of relevant experience and expertise, naming managers, supervisors and teams responsible for and allocated to the Contract. *[922.4]*

9 The design method used [eg Road Note 39] and a design proposal for each location. *[922.2]*

10 Estimated design life of the Surface Dressing for each location. *[922.2]*

11 For the performance specification, the results of any other tests or other data the Contractor considers would assist the Overseeing Organisation in assessing the technical merit of the design.

12 An 'As Built Manual' as specified within 4 weeks of the completion of the works. *[922.18]*.

Binder Data Sheet - Appendix 7/3	**Surface Dressing - Performance Specification**		
Manufacturer of Binder:	Product name:		
Binder type:	Batch no:		
Binder Grade (highlight as required)	Conventional	Intermediate	
	Premium	Super-premium	
Binder source:	**Supplied Binder**	**Aged binder**	**Recovered Binder**
Test	As supplied to site	Recovered in accordance with Clause 923	Aged in accordance with Clause 923
Penetration at 25°C 0,1 mm (100g and 5 secs)			
Penetration at 5°C 0,1 mm (200g and 60 secs)			
Vialit pendulum cohesion see Clause 939 maximum peak value J/cm^2	†#	#	#
Product identification test sub-Clause 922.6. Complex shear (stiffness) modulus (G*) and phase angle (δ) data. See Clause 928.		#	#
Minimum viscosity STV 4 mm cup at 40°C or Redwood II at 85°C; (required to prevent binder flow on road - normal camber)	‡		
Other properties the Contractor considers useful			
Weather limits - information from binder manufacturer: road or air temperatures; humidity; wind chill adjustment; tolerance of surface dampness; etc.	Temperature max: Temperature min: Other:		

Where indicated with # the Contractor shall attach a graphical output to this schedule.

† Cutback binders only.

‡ Emulsions only.

Shaded cells do not require data.

NG SAMPLE APPENDIX 7/3: SURFACE DRESSING - PERFORMANCE SPECIFICATION

SHEET 3: TAIT Certificate Information to be provided by the Contractor

The Contractor shall provide the TAIT Certificate containing at least the following information with his tender:

Company Name and Address:

QA reference number and certifying body:

TAIT reference number:

Date of TAIT:

Self-certified within the Sector Scheme for the Production of Surface Dressing or certified by British Board of Agrément (BBA)

Proprietary Name:

Description of material:

Design procedure or method:

Material thickness (if applicable):

Macrotexture depth at 1 year (as measured and as a percentage of the initial value):

Colour retention (if applicable):

Other optional claims as declared by the installer (eg Profile improvement, reduced tyre-road noise emission or RSI, ability to accommodate a variable substrate, skid resistance if greater than PSV and macrotexture would indicate, etc.)

Expected life (Estimated Design Life)

Field of application for the particular material:

- Traffic - maximum commercial vehicles per lane per day:
- Traffic - total traffic per lane per day:
- Traffic - Speed limit:
- Degree of Site difficulty, see HD 36 (DMRB 7.5.1) for categories:

Constraints on application for the particular material:

- Time of year:
- Temperature:
- Variability of existing surface hardness or type:
- Other as declared by the installer:

Name and signature of company representative responsible for the TAIT:

APPENDIX 7/4: BOND COATS AND OTHER BITUMINOUS SPRAYS

1. Bond coats in accordance with Clause 920 shall be used beneath all bituminous layers where laid on any other bituminous material or concrete.

Information to be Provided by the Contractor

2. The Contractor shall provide the following information with his quotation, or prior to the commencement of the Works:

(i) the product or products he proposes to use together with their data sheets, product identification data, cohesivity data as specified;

(ii) for each product, a copy of the BS EN ISO 9001 certificate showing the name of the manufacturer, the name of the certification body and the reference number and date of the certificate;

(iii) the spraying equipment proposed, and a test certificate;

(iv) the source or sources of blinding material proposed;

(v) contingency plans in the event of any breakdown;

(vi) the results of any other tests or other data the Contractor considers would assist the Overseeing Organisation in assessing the technical merit of the treatment such as

(a) tackiness tests and/or traffickability time and methods of test or

(b) breaking time test results for different weather conditions and substrates.

3. The rate of spread shall be 0.3 kg/m^2 residual binder where the substrate is new asphalt and 0.4 kg/m^2 when the substrate is old or has had sufficient traffic over it to have removed a significant proportion of the surface binder. The residual binder for various grades of emulsion is shown in table 7/4.

4 the bond coat shall be sprayed not more than 24 hours prior to commencing laying on D roads and immediately after lane is closed to traffic for A, B and C roads.

Table 7.4 Rate of spread of bond coat

Class of polymer modified bitumen emulsion	Residual binder 0.3 kg/m^2	Residual binder 0.4 kg/m^2
C50PB	0.6 l/m^2	0.8 l/m^2
C60PB	0.5 l/m^2	0.67 l/m^2
C65PB	0.46 l/m^2	0.62 l/m^2

The polymer modified bitumen emulsion shall have a minimum cohesion of 1.0 J/cm^2

Binder Data Sheet	**Bond Coats, Tack Coats and Other Bituminous Sprays**
Manufacturer of Binder:	Product Name:
Binder Type:	Batch No:
Binder Grade (highlight as required) Conventional Intermediate Premium Super-premium Non-tack Other	

Binder **Source ►** **Test** **▼**	**Recovered Binder** Recovered in accordance with Clause 955	**Recovered Binder After Ageing Test** Aged in accordance with Clause 955
Penetration at 25°C 0,1 mm (100g and 5 secs)		
Penetration at 5°C 0,1 mm (200g and 60 secs)		
Vialit pendulum cohesion see Clause 957 maximum peak value J/cm^2	The Contractor shall attach a Report and graphical output to this schedule as specified in Clause 957	The Contractor shall attach a Report and graphical output to this schedule as specified in Clause 957
Product identification test. The provision of data for identification and ageing is optional for unmodified bituminous emulsions to BS EN 13808 and for bitumen to BS EN 12591 and cutback bitumen to BS EN 15322. Complex shear (stiffness) modulus (G*) and phase angle (ä) data. See Clause 956.	The Contractor shall attach a Report and graphical output to this schedule as specified in Clause 956	The Contractor shall attach a Report and graphical output to this schedule as specified in Clause 956
Other properties the Contractor considers useful: Minimum Binder Content Binder temperature range for spray application Emulsion Properties and Viscosity Break time		

Breaking Agent type Weather limits - information from binder manufacturer: road or air temperatures; humidity; wind chill adjustment; tolerance of surface dampness; etc. Temperature max: Temperature min: Other:	

APPENDIX 7/6: BREAKING UP OR PERFORATION OF EXISTING PAVEMENT

1. The details of breaking up or perforation of existing pavement are shown on Drawing Nos. [insert nos].

NG SAMPLE APPENDIX 7/7: SLURRY SURFACING INCORPORATING MICROSURFACING

SHEET 1: Information to be provided by the compiler *[Note to compiler: Complete one sheet per section]*

1 Location *[918.1 - eg road number, name, OS grid reference of start and finish, lane include a plan where appropriate]*

2 Traffic count *[918.1 - total and commercial vehicle count required for each lane]*

3 Traffic speed, 85 percentile and site speed limit

4 Category of site *[918.1 - letter category from HD 36 (DMRB 7.5.1)]*

5 Description of existing surface *[918.2 and 918.4 - Macrotexture, existing defects, variability, etc.]*

6 Thickness of Slurry Surfacing *[918.11, normally not required, nominal 15 mm, for microsurfacing]*

7 Guarantee period if not 2 years *[1 year, or 2 years for roads carrying traffic towards the upper limit permitted using this Clause]*

8 Minimum declared PSV of coarse aggregate *[918.6, HD 36 (DMRB 7.5.1)]*

9 Maximum AAV of coarse aggregate *[918.6, HD 36 (DMRB 7.5.1)]*

10 Preparation and masking requirements *[918.13, 918.18 and 918.21]*

11 Definition of colour required *[918.8]*

12 Surface finish required for footways (if not by transverse brushing) *[918.21]*

13 Minimum macrotexture depth at end of guarantee period *[918.31 and NG 9/1 - eg. minimum 1 mm for more than 50 cv/lane/day roads with a speed limit of 50 mph, no requirement may be specified for very lightly trafficked low-speed carriageways or footways]*

14 Maximum texture depth after 4 weeks trafficking *[918.31 - only required where tyre-road noise emission is a problem normally 3 mm Sand Patch texture depth]*

15 Maximum percentage decrease in macrotexture initially measured and at the end of the guarantee period *[918.2 and 918.31 - normally 40%]*

16 Category of area defects (% area affected) acceptable *[918.33 - Table NG 9/2]*

17 Category of linear defects (m per 100 m) acceptable *[918.33 - Table NG 9/3]*

18 Class of transverse regularity *[918.32 and Table NG 9/5 - eg. Class 0 if only sealing and improvement to surface characteristics are required]*

19 Class of longitudinal regularity *[918.32 and Table NG 9/7 - eg. Class 0 if only sealing and improvement to surface characteristics are required]*

20 Special restrictions *[918.17, 918.24, 918.28 and 918.29 - for example: minimum road surface temperature at which working permitted is 4ºC and maximum is 40ºC]*

[Note to compiler: If a number of sites are involved then it would be convenient to set out the above data in tabular form with columns left for contractor's proposals]

NG SAMPLE APPENDIX 7/7: SLURRY SURFACING INCORPORATING MICROSURFACING

SHEET 2: Information to be provided by the Contractor:

1 A copy of BS EN ISO 9001 certificate showing at least the name of the Company / subcontractor, the name of the certification body and the reference number and date of the certificate including the requirements of Appendix A of BS EN 12273. As copy of the relevant part of the company Quality Assurance (QA) document showing the appropriate scope and limitations of the certification. The *Service Manager* will wish to inspect all or any of the company's / subcontractors QA documentation as part of the *Service Managers* acceptance of any sub-contractors to satisfy himself on the nature of the QA systems of the company's / subcontractors material suppliers.

2 Design Proposal for Slurry Surfacing for each location and target binder content with tolerances. *[918.2]*

3 Estimated Design Life of the Slurry Surfacing for each location. *[918.2]*

4 A copy of the TAIT Certificate in accordance with BS EN 12273 for each proposed system together with its supporting data. In the event of no certificates being issued a statement of any previous applications on roads similar in site type to the Contract sites containing the same data as listed in NG Sample Appendix Sheet 3. *[918.4]*

5 A method statement for each Task Order or group of similar Task Orders showing how it is proposed to carry out the works in conformance with the Service Information. *[Contractors will be expected to commit enough resources to carry out the proposed design; the type and age of the Slurry Surfacing Machine should be detailed].*

6 Proposed source or sources of coarse aggregate together with statements of properties including target grading, declared PSV and AAV. *[918.6]*

7 Proposed source or sources of fine aggregate including target grading and other constituents together with statements of properties. *[918.6]*

8 Proposed binder together with data sheets and cohesivity data. For work carried out for the Highways Agency, a copy of all the data should be handed to the Overseeing Organisation, to be forwarded to: Pavement Engineering Team at Highways Agency, Bedford Office. *[918.7. Note to compiler: a suitable form for the provision of data is attached to this Appendix, other layouts are permitted but all the required data should be supplied]*

9 Proposals for traffic control and aftercare for each site, and reaction times for: carrying out remedial measures; sweeping; and site visits with the Overseeing Organisation. *[918 15, 918.18, 918.29]*

10 Contingency plans in the event of any breakdown of plant or failure of the Slurry Surfacing. *[918.28]*

11 An ‘As Built Manual’ as specified. *[918.30]*

12 If available the following information should be provided in order to assist the Overseeing Organisation to assess the technical merits of the Design Proposal:

(i) Test method for binder content.

(ii) Test for thickness of Slurry Surfacing.

(iii)Traffickability time, including method of test.

(iv)Wheel tracking test results at 45ºC or 60ºC or other suitable measure of the ability of the proposed system to resist deformation and flow.

(v) Water sensitivity test results from the test used by BBA/HAPAS thin surfacing Guidelines Document or from wet wheel tracking (whichever is available).

(vi)Permeability test carried out on the system, if it is claimed that the process seals the existing surface together with the method of test.

(vii) Accelerated ageing test results in accordance with the appropriate BBA/HAPAS test.

(viii) Bond test results using the BBA/HAPAS test on either a bituminous or a concrete substrate as appropriate to the site or Bond Coat binder BBA/HAPAS certificate.

(ix) Shaking Abrasion test results.

(x) Slurry surfacing mix cohesion.

(xi)The results of any other tests or other data the Contractor considers would assist the Overseeing Organisation in assessing the technical merit of the Design Proposal.

Binder Data Sheet - Appendix 7/7 (08/08)	**Slurry Surfacing Incorporating Microsurfacing**		
Manufacturer of Binder:	Product name:		
Binder type:	Batch no:		
Binder source:			
Test	Binder as supplied to site	Recovered binder in accordance with Clause 955	Aged binder in accordance with Clause 955
Penetration at 25°C 0,1 mm (100g and 5 secs)			
Penetration at 5°C 0,1 mm (200g and 60 secs)			
Vialit pendulum cohesion to BS EN 13588 maximum peak value J/cm^2		#	#
Product identification test sub-Clause 918.7. Complex shear (stiffness) modulus (G*) and phase angle (□) data. BS EN 14770		#	#
Other properties the Contractor considers useful			
Weather limits - information from binder manufacturer: road or air temperatures; humidity; wind chill adjustment; etc.	Temperature max: Temperature min: Other:		

Where indicated with # the Contractor shall attach a graphical output to this schedule.

Shaded cells do not require data.

NG SAMPLE APPENDIX 7/7: (05/01) **SLURRY SURFACING INCORPORATING MICROSURFACING**

SHEET 3: TAIT Certificate: Information to be provided by the Contractor

The Contractor shall provide the TAIT Certificate containing at least the following information with his tender:

Company Name and Address:

QA reference number and certifying body:

TAIT reference number:

Date of TAIT:

Proprietary Name:

Description of material:

Design procedure or method:

Material thickness (if applicable):

Macrotexture depth at 1 year (as measured and as a percentage of the initial value):

Colour retention (if applicable):

Other optional claims as declared by the installer (eg Profile improvement, reduced tyre-road noise emission or RSI, ability to accommodate a variable substrate, skid resistance if greater than PSV and macrotexture would indicate, etc.):

Expected life (Estimated Design Life):

Field of application for the particular material:

Traffic - maximum commercial vehicles per lane per day:
Traffic - total traffic per lane per day:
Traffic - Speed limit: Degree of Site difficulty, see HD 36 (DMRB 7.5.1) for categories:

Constraints on application for the particular material:

Time of year:
Temperature:
Variability of existing surface hardness or type:
Other as declared by the installer:

Name and signature of company representative responsible for the TAIT:

APPENDIX 7/8: RETREAD

1 The compiler should state the surface course to be used. This will usually be a 6 mm surface dressing. The latest date when the surfacing should be completed should also be inserted by the compiler. Guidance on this can be found in BS 434-2.

2 The contractor should include for an average quantity of imported stone of 50 kg/m^2

APPENDIX 7/9: COLD-MILLING (PLANING) OF BITUMINOUS BOUND FLEXIBLE PAVEMENT

1. Refer to Appendix 7/2 for general requirements of trimming of pavements.

2. Profile planing shall be carried out in those locations shown on Drawing Nos. [insert nos] to enable the full depth of surface course specified in Appendix 7/1 to be laid.

APPENDIX 7/11: OVERBAND AND INLAID CRACK SEALING SYSTEMS

Prior to use the following data will be required:

A copy of the HAPAS certificate

APPENDIX 7/22 : REPAIRS TO POTHOLES

This work will be carried out by either Type 1 or Type 2 Gangs as appropriate. Planned patching will use 45/10F HRA if hand laid and 55/10F HRA if machine laid. Machine laying is preferred and is mandatory for areas above 50 m^2

General

1. a) All loose material shall be removed before filling the hole.

b) All standing water shall be removed before filling the hole.

c) The filling material shall be compacted by a suitable means.

d) The surface of the compacted material shall be level with that of the adjacent road.

Road stud holes

2. Fill road stud socket with 6 mm bituminous instant road repair material or equivalent.

Holes in Paved Areas

3. For holes less than 0.5 m^2 - fill with approved 6 mm bituminous instant road repair material or other approved processes.

4. For holes greater than 0.5 m^2 - fill with 6 mm nominal size dense bitumen macadam surface course.

5. Holes shall be backfilled with materials compacted to refusal with a circular headed vibrating hammer in layers not exceeding 75 mm thick, or similar approved process.

APPENDIX 7/23: HIGH FRICTION SURFACING

General

1. The use of screeded high friction materials is not permitted in Coventry City and is deprecated by Warwickshire.

2. Warwickshire has a strategy of minimising the use of high friction surfacing by using high quality surface dressing in its place wherever possible.

3. The specifier should state the minimum class for high friction surfacing for the site.

4. The following performance criteria shall be met using visual assessment:

Parameter	**Requirement in the wheel tracks***	**Requirement outside the wheel tracks***
Fatting up after 2 weeks and any time up to 2 years; P_1	Not more than 0.5 %	Not more than 2.0%
Delamination at 2 years; P_2	Not more than 0.5 %	Not more than 2.0%
Chipping loss at 2 years; P_3	Not more than 3%	Not more than 6%
'Grinning' at 2 years; P_4	Not more than 3%	Not more than 6%

*where the location of the wheel track is indeterminate, as on roundabouts, the whole area shall meet the wheel track criteria.

Test methods for visual assessment of High Friction Surfacing

5. These are based on tests from BS EN 12272-2 and EN 12274-8 for surface dressing and slurry surfacing respectively which are already in use in the SHW for those materials. Minor modifications are needed to enable their use for high friction surfacing.

6. The four tests to be used are:

a) For fatting up – the test for fatting up EN 12274-8 (P_1 in that standard)

b) For delamination – the delamination test from EN 12274-8 (P_2 in that standard)

c) For chipping loss – the fretting test from BS EN 12272-2 (P_3 in that standard)

d) For 'grinning' (see note) - the test for groups of small repetitive defects from EN 12274-8 (P_4 in that standard) except that the minimum defect size shall be 10 mm and not 10D.

Note - 'grinning' is where the high friction surface has worn off the top of chippings in the underlying surface and they are 'grinning' through the high friction surfacing.