Warwickshire County Council

County Road Construction Strategy – 2022

Delivering a safe and sustainable highway network

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Working for Warwickshire

This document provides guidance for the design, construction and maintenance of the local highway network in the County of Warwickshire. This strategy shall be implemented from the date of publication and supersedes previous versions. Any project underway or in design at the implementation date may continue under previous guidance if any changes required would have time or cost consequences.

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Abbreviations

AAV	Aggregate Abrasion Value
AC	Asphaltic Concrete
ADEPT	Association of Directors of Environment, Economy, Planning and Transport
BSI	British Standards Institute
CBR	California Bearing Ratio
CSS	County Surveyors Society
Cv/l/d	Commercial Vehicles per Lane per Day
DMRB	Design Manual for Roads and Bridges
HAPAS	Highway Authorities Product Approval Scheme
HAUC	Highway Authorities and Utilities Committee
HFS	High Friction Surfacing
HGV	Heavy Goods Vehicle
HRA	Hot Rolled Asphalt
IL	Investigatory Level
MCHW	Manual of Contract documents for Highway Works
MSA	Million Standard Axles
PPV	Polished Paver Value
PSV	Polished Stone Value
S278	Section 278 (of the Highways Act)
S38	Section 38 (of the Highways Act)
SCRIM	Sideways force Coefficient Routine Investigation Machine
SHW	Specification for Highway Works
SMA	Stone Mastic Asphalt
SRN	Strategic Road Network
TRL	Transport Research Laboratory
TM	Traffic Management
TSC	Thin Surface Course
WCC	Warwickshire County Council

1. Introduction

Background

1.1. Warwickshire has maintained a formal Highway Construction Strategy since at least 1998, which has provided guidance on how Warwickshire as the local road Highway Authority, want to construct and maintain the roads for which it is responsible. Some designs, construction methods and materials differ from those given in national standards such as the DMRB and the SHW.

1.2. Credit should be given to Charles Catt FCIHT FIAT, who wrote the first of these Strategy documents and continued to update and maintain them until 2015. Charles was Warwickshire's Laboratory Manager and Materials Engineer between 1967 and 1994. Following early retirement, he continued to work in the industry as a consultant with organisations such as CSS (now ADEPT), BSI and TRL as well as WCC. Charles sadly passed away in December 2018.

1.3. Whilst this document is completely new and not just an update of previous versions, it builds on those Charles Catt authored versions and many of the Warwickshire specific adaptations are carried forward, as they are based on solid engineering judgement, experience and experimentation.

1.4. It is worth pointing out that, whilst some aspects of this Strategy depart from National Standards, there is nothing wrong with those standards. Even the departures have their basis in the National Standards, but there has been some tailoring to suit the particular characteristics of Warwickshire's roads, soil types, material availability and maintenance needs. There is also a degree of simplification to help engineers and technicians make informed decisions that suit the local environment.

Layout and use of this Strategy

1.5. This document is split into chapters which relate to key aspects of design and construction of a highway. Some of them relate to a DMRB Standard, in which case the DMRB Standard to which it relates will be given in the chapter title in brackets e.g. (CD 225).

1.6. Each chapter will provide guidance about the use of the National Standard or whether Warwickshire adopts a different approach. In some instances, the approach may be different for different situations. For example, with a large scheme to build a significant section of new road, the full DMRB approach may be taken, whilst for small or maintenance projects a tailored Warwickshire approach would be favoured. For projects on the Strategic Network (Trunk Roads) under the control of National Highways (formerly Highways England) the DMRB is the default.

1.7. There are chapters which cover specific Highway Authority functions, such as Adoptable Roads (Section 38's) and Highway Maintenance. This is because there are some specific departures from National Standards which apply to these functions. Both our Development Regulation and County Highways Sections have adopted different approaches that have developed over many decades, which are designed to ensure the most cost-effective process is followed. This helps to protect Warwickshire Council Taxpayers from excessive future maintenance costs.

1.8. Some parts of the chapters referred to in paragraph 1.7 will have simple references to certain paragraphs of other chapters, to reduce repetition.

1.9. There is a "General" chapter which captures a number of further aspects not picked up in other chapters. This covers subjects such as material trials and sustainability. These things are important to Warwickshire and deserve some specific guidance.

1.10. The final chapter contains the Annexes to the main document. Here reside some additional papers to support aspects of this Strategy and to highlight the justifications for departing from National Standards.

2. New Road Pavement Foundations (CD 225)

2.1. The **DMRB** completed a radical change in April 2020 and as part of it the new **CD 225** was introduced. This standard replaced the previous **IAN 73** which in turn had been a temporary replacement for **HD25**. **CD 225** represents a much bigger change and brings with it some new ideas and a new design methodology.

2.2. The documents forming the "**Standards for Highways**" as stated on its opening page relates "*to the design, assessment and operation of motorway and all-purpose trunk roads in the United Kingdom*". It may not always be appropriate for lower classification local roads which are the responsibility of a local Highway Authority.

2.3. In Warwickshire there are instances when **CD 225** can be applied and instances when a local alternative approach is taken. The different approaches are applied as shown below:

CD 225 applied:

i) when a project is undertaken on a Trunk Road;
ii) when a substantial length of new road is to be built;
iii) for a project involving large areas of new construction on the existing road network.

Warwickshire approach to be applied:

iv) for schemes involving small areas of new construction;
v) for most S278 schemes unless any of i), ii) or iii) apply;
vi) for maintenance schemes;
vii) for adoptable roads (S38's).

2.4. When CD 225 is to be applied then the rest of the DMRB will apply to the design and implementation of the project apart from the choice of surface course material. For this please refer to Chapter 4. **For trunk road projects**, none of this strategy is required as the **default is the DMRB**.

The Warwickshire Approach

2.5. For all projects not set out in 2.3 i), ii) or iii), the Warwickshire approach shall be taken. For projects described in 2.3 ii) or iii) the Warwickshire approach can still be applied and indeed may be a better option from an engineering point of view.

2.6. A simple selection process from **Tables 2A – 2C** will give you a capping and sub-base design depending on the level of detail of information that you have and the size of the project.

2.7. The background and specification for Warwickshire sub-bases, **W150 and W75** is given in Chapter 10 Annex B. 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 material**. 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 4** may be used but only those containing at least 80% of bituminous planings. **W75** is normally used where space is limited such as in strip widening and where significant proportion of the material has to be manhandled, or where the overall foundation thickness is not sufficient for **W150 to be laid at least 300mm thick. W75 should not be laid less than 150mm thick**. **W150** is preferred where machine placing is used such as half lane widths or more.

2.8. The specification for W75 and W150 is given in Warwickshire Specification Clause 890AR.

2.9. Warwickshire advocates always carrying out some form of **ground investigation** before proceeding with any project which involves new construction. Making rash assumptions may lead to serious problems at a later stage which might cause significant delay and cost, or even worse, corner cutting. Even some simple work to determine the sub-soil type across the site may be sufficient for a small project. **Trial holes** and possibly some **CBR tests** using a Mexecone Penetrometer is a good basis to allow informed decisions to be made. Large projects really must have a more comprehensive **geotechnical investigation.**

Table 2A - Default sub-base Thicknesses

CBR	Total sub-base thickness (nominal)	W sub-base	Type 1 or 3 Sub-base or bituminous asphalt planings (Type 4)
%	mm	mm (minimum)	mm (maximum)
<2½ (heavy clay)	Where CBR is less than 2½% a more stringent geotechnical investigation will be required. The guidance given in CD 225 must be followed.		
2½-5 (Keuper Marl)	500	350	150
5-15 (non-plastic sands)	300	150	150
>15 (non-plastic gravels)	200	0	200

Note 1: See paragraph 2.7 for guidance on choosing between W75 and W150.

Note 2: The thickness of the ‘W’ sub-bases should be maximised within each category with types 1 - 4 reduced to the role of a regulating layer.

Note 3: Mexecone Penetrometer is only really useful when testing fine graded materials such as clay, silt or sand. Stoney or gravelly soils may give false readings. There is a lot of clay in Warwickshire so in fact the Mexecone is a pretty handy and versatile device.

2.10. **Table 2A** is for use on smaller projects where potentially a very basic ground investigation has been done. On a small site it is likely (but not certain) that the ground conditions will be similar across the site and can be categorised as one of the basic soil types listed and hence within a CBR range suggested. This should be backed up with **CBR testing** using Mexecone Penetrometer or other testing method. Always use the lower CBR value for design.

Table 2B - Design CBR

Soil type	**PI**	**Construction conditions**	
	%	**Poor**	**Good**
Heavy Clay (typically Lias)	70	1.5	2.5
	60	1.5	2.5
	50	1.5	2.5
(typically Mercia mudstone (marl))	40	2	3.5
Silty Clay	30	2.5	6
Sandy Clay	20	2.5	8
	10	1.5	8
Silt		1	2
Non-plastic Sands		20	40
Sandy Gravels		60	60

Note 1: PI is plasticity index, see BS 1377:1990

Note 2: Table 2B is a simplified version from TRRL Report LR 1132.

Note 3: Construction conditions; Poor = high water table, thin construction, poor weather; Good = low water table, thick construction, good weather. This gives an idea of the range of values that may be achieved.

Table 2C - 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 4)
%	mm	mm (minimum)	mm (maximum)
<2½	450 + other measures	300	150
2½	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
>15	200	0	200

Note 1: A large contract is one where there is a laboratory on site or regular lab attendance capable of carrying out the large amount of testing required.

Note 2: Incinerator Bottom Ash Aggregate (IBAA) and all materials containing Incinerator Bottom Ash (IBA) are **not** permitted.

2.11. **Tables 2B & 2C** are for use on larger projects where a more stringent ground investigation will have been carried out. On larger sites the sub-soil type may not be consistent across the site, particularly if cuttings and embankments are involved. **Table 2B** gives **typical CBR** values for a larger range of soil types and for a range from poor to good construction conditions. Again, this should be backed up by site **CBR testing**. Design stage investigation should give a good idea of what to expect and will be the basis for design and pavement thicknesses given in contract clauses. However, testing during construction may identify soft area's which will need additional treatment.

2.12. Please be aware that this is not the end of the design as one key factor to producing a long-life foundation is a **well-drained foundation**. You must refer to Chapter 6 to ensure you have considered and implemented a means of draining your pavement foundation.

3. New Pavement Structural Layers (CD 226)

3.1. The April 2020 publication of the new **DMRB** gave us the brand-new **CD 226**. Again, this brings some significant changes from **HD26** which it replaced. There is no point going into the changes brought about by CD 226 in this document, as it is freely available on-line for all to use. However, it does present Warwickshire with a problem, since for pavement design we embraced the **design charts within HD26**, and our default binder grade was **100/150pen**. This binder grade no longer features on the charts in **CD 226, only 40/60pen is presented.**

3.2. Part of the reasoning for the default use of **100/150pen** binder grade in Warwickshire is no longer valid and there is some merit in using the stiffer **40/60pen** binder which provides a thinner pavement and hence reduces excavation and bituminous material use, so has sustainability and cost benefits. However, these benefits are best realised on larger schemes where there are significant areas of new construction. For smaller projects and for maintenance work, where we are working on or improving part of the existing road network, then **sticking with 100/150pen binder is likely to be a more sensible option**. To roughly convert a CD 226 40/60pen design to 100/150pen design, you will need to multiply the resulting thickness by 1.2 (i.e. add 20%). This only works beyond 2 MSA design traffic.

3.3. The **reason for retaining** the use of **100/150pen** binder is summarised below:

- i) Many of Warwickshire's roads are old evolved roads, never designed and they are constructed with soft, flexible materials. 100/150pen binder is more flexible and more in keeping with these existing roads;
- ii) Most of our minor roads can be classed as lightly trafficked so rutting is rarely a problem, hence a stiff binder is not necessary;
- iii) The softer binder is more workable, so more forgiving in winter and in small or intricate areas;
- iv) A surface course overlay with a stiff binder over a softer flexible material may be prone to cracking in the early years of its life.

3.4. There is, however sound **justification for using 40/60pen** binder grade in new construction and even maintenance. The 2 main reasons to consider using the stiffer binder are; hotter summer temperatures which means risk of rutting is increasing; and the stiffer binder designs are thinner and hence use less material. There is likely to be little or no cost difference for similar materials with the different binder grades, so less thickness means less material, less cost, less energy used and hence less harmful emissions. Also, binder hardens during mixing and continues to harden in the pavement. Research has shown that a 100pen binder after several years in service hardens to about 30pen. So, after several years in service, there is probably little difference in binder hardness between what started as 100/150 pen and 40/60pen binder.

3.5. The layer thickness for structural layers are shown in **Table 3A**. The design life is deemed to be **40 years**. For Adoptable Roads (S38's) please see Chapter 7.

Table 3A - 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* for 40/60pen *120 for 100/150pen*	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 10mm SMA surfacing	140* for 40/60pen *185 for 100/150pen.*	60**
Above 5 msa (i.e. 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 CD 226 Fig. 2.2 less thickness of structural surfacing. When designing for 100/150pen binder grade add 20% to CD 226 40/60pen design thickness.	

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

*** Binder penetration grade must be consistent throughout the pavement thickness. If 40/60pen is used in base then it should also be used for binder and surface course.*

3.6. The **base** shall generally be asphalt concrete **AC 32 dense base recipe mixture** to BS EN 13108-1 and PD 6691. Design mixtures may be appropriate for large new construction projects but only with approval by the overseeing organisation. The use of gravel aggregate is not permitted. EME2 is unlikely to be ever suitable for Warwickshire's roads as design costs are high and any advantage of savings in thickness would be negligible over 40/60pen.

3.7. The **binder course** shall generally by asphalt concrete **AC 20 dense bin recipe mixture** to BS EN 13108-1 and PD 6691. Design mixtures may be appropriate for large new construction projects but only with approval by the overseeing organisation. The use of gravel aggregate is not permitted.

3.8. **Bond coat** in accordance with **clause 920 of the SHW** shall be used between all structural layers. To clarify this often-disregarded requirement, the bond coat **must be applied between all layers** regardless of whether the previous layer was laid 10 years ago, last week, yesterday or an hour ago. For more information on bond coats and spread rates see **BS 594987** Section 5.5. Contract **clause 977AR** specifies the bond requirements.

Note: A bond coat is a polymer modified emulsion and should not be confused with tack coats which are unmodified and have not been permitted for some time.

3.9. The level of **compaction** shall be measured by means of void content. The compaction specification is given in **clause 973AR**, which is based on **clause 929 of the SHW**. Clause 973AR shows the mean of a set of 6 cores shall **not exceed 6%**, which is slightly less than the figure in SHW clause 929. In Warwickshire it has long been established that **low voids means longer life**. It has also been established that locally sourced materials are easily able to achieve the low voids specified in clause 973AR. The specification for compaction close to a joint is in line with **SHW clause 903** which relaxes the voids content by up to 2% above that of the main mat.

4. Pavement Surfacing (CD 236)

4.1. The April 2020 publication of the new DMRB included the new CD 236. This standard replaced the previous HD36. The new standard is different but not dramatically so and not in a way that will affect what we do on the local roads of Warwickshire. One key change to note is that Hot Rolled Asphalt (HRA) is back on the menu for the Strategic Road Network (SRN) for both new construction and maintenance operations. The other default material is Thin Surface Course to clause 942 of the SHW, as it has been for a number of years.

4.2. In general, except where carrying out a project on the Trunk Road network, we depart from **CD 236** in our selection of surface course materials. We generally select from **2 main options: SMA 10 or 55/10 HRA**. A guide to the selection of material is given in **Table 4A** below.

Table 4A - Summary of preferred surfacing for new work

Speed limit (mph)	Traffic 100 cv/l/d and below	Traffic 100 - 500 cv/l/d	Traffic above 500 cv/l/d or over 10 msa in design life.
20	Hot Rolled Asphalt 55/10F surf 100/150 or 40/60	Hot Rolled Asphalt 55/10F surf 100/150 or 40/60	SMA 10 (surf) to BS EN 13108-5
30			
40			
50		SMA 10 (surf) to BS EN 13108-5	
60			
70			

Note: where new surfacing is being inserted into an existing road (e.g. a right turn lane) it is usually appropriate to match the surface type to the existing, except if it is surface dressed or if the project includes resurfacing the full carriageway width over a significant distance.

4.3. It should be noted that **Table 4A** is a guide and should be the initial consideration, but other factors may justify a different decision, such as is outlined in the accompanying note. See also paragraph 4.8.

4.4. On roads carrying **more than 100 cv/l/d** with a speed limit **above 40mph** and for all heavily trafficked roads, 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 **clause 976AR**. **HAPAS Thin Surface Courses** may be used but only those that comply with the compaction requirements of **clause 973AR**. 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. On roads **not** described in **4.4**, the first choice of surfacing material shall be **Hot Rolled Asphalt HRA 55/10** surf 100/150 or 40/60 to BS EN 13108-4 as described in PD 6691.

4.6. Experience since about 2010 has shown that the **dense SMA 10 surface courses** are very durable even when used on smaller diameter roundabouts and in fact can now prove more durable than HRA 55/10. On highly stressed sites consideration should be given to the use of an **SMA 10** surface course with appropriate binder to ensure high density and low voids.

4.7. **HRA 55/10F** has been the staple surfacing material in Warwickshire for many years and was in the early days (still occasionally today) referred to as Medium Temperature Asphalt (MTA). The “F” designation refers to “Fine” and “C” designation refers to “Course”. Type F was historically preferred because of anecdotal evidence that it was more workable and hence easier to compact. **Recent trials with HRA 55/10C** has proved to be equally **satisfactory**. The “Fine” & “Coarse” applies only to its constituent aggregate which passes the 2.36mm sieve so very much the fine end of the scale and up to only 6% of the aggregate. In those recent trials the type C version looked no different to the type F widely used and so either is now acceptable.

4.8. As an **alternative** surfacing option and partly in line with CD 236, the use of **Hot Rolled Asphalt and chippings** may be used. The specification to be used shall be: **HRA 30/14F 40/60 recipe** Schedule 1A as specified in BS PD 6691 Annex C. The chippings shall conform to BS PD 6691 table C5 20mm 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 **40/60pen** but for lighter trafficked roads where rutting is unlikely to be a problem **100/150pen may be used** with particular advantage in cooler conditions.

4.9. See **Chapter 8 Highway Maintenance; for other surfacing options**, which are generally only used in this field of operations. Highway maintenance is an area which often requires a range of different materials and treatments to best deal with a varied array of road types, failure modes and budgetary constraints.

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

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

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

4.12. The **polished stone value (PSV)** shall be specified in accordance with **Table 4B**. The minimum polished stone values given in the table are for 10mm aggregate in surface dressing, thin surfacing and, where the speed limit is 30mph or less for 55/10 asphalt.

4.13. The minimum PSVs given in the table shall be increased by 5 where 14mm or 20mm aggregate is used in any surfacing and where 55/10 asphalt is used on roads with 40mph or higher speed limits (65 will be increased to 68+).

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

Table 4B – Minimum Polished Stone Value of Chippings or Coarse Aggregate in Surface Courses.

Site Group	Site Description	Minimum PSV required for given IL, traffic level and site.											
		Risk Rating		Traffic (cv/lane/day) at design life									
			IL	0-250	251-500	501-750	751-1000	1001-2000	2001-3000	3001-4000	4001-5000	5001-6000	Over 6000
B	Dual C/way one way, non-event.	L	0.3	50	50	50	50	50	55 (50)	55 (50)	60 (53)	65 (63)	65(63)
		S	0.35	50	50	50	50	50	60 (53)	60 (53)	60 (53)	65 (63)	65 (63)
		H	0.4	50	50	50	55 (50)	60 (53)	65 (58)	65 (58)	65 (58)	65 (63)	68+
C	Single carriageway non-event.	L	0.35	50	50	50	55 (50)	55 (50)	60 (53)	60 (53)	65 (58)	65 (63)	65 (63)
		S	0.4	55 (53)	60 (53)	60 (58)	65 (58)	65 (58)	68+(63)	68+ (63)	68+ (63)	68+	68+
		H	0.45	60 (53)	60 (53)	65 (58)	65 (58)	68+ (63)	68+ (63)	68+ (63)	68+ (63)	68+	68+
Q	Approaches to and across minor and major junctions. Approaches to roundabouts and traffic signals.	L	0.45	60	65	65	68+	68+	68+	68+	68+	68+	HFS
		S	0.50	65	65	65	68+	68+	68+	HFS	HFS	HFS	HFS
		H	0.55	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS
K	Approaches to pedestrian crossings and other high-risk situations.	S	0.50	65	65	65	68+	68+	68+	HFS	HFS	HFS	HFS
		H	0.55	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS
R	Roundabouts.	S	0.45	50	55	60	60	65	65	68+	68+	68+	68+
		H	0.5	68+	68+	68+	68+	68+	68+	68+	68+	68+	68+
G1	Gradient 5-10%, longer than 50m. N/A to uphill gradients on dual/one-way sections.	S	0.45	55	60	60	65	65	68+	68+	68+	68+	68+
		H	0.50	60	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS
G2	Gradient >10%, longer than 50m. N/A to uphill gradients on dual/one-way sections.	L	0.45	55	60	60	65	65	68+	68+	68+	68+	68+
		S	0.50	60	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS
		H	0.55	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS
S1	Bends radius <500m & speed limit ≥ 50mph, dual c/way (one-way traffic).	S	0.45	50	55	60	60	65	65	68+	68+	HFS	HFS
		H	0.5	68+	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS
S2	Bends radius <500m, speed limit ≥50mph, 2-way traffic.	L	0.45	50	55	60	60	65	65	68+	68+	HFS	HFS
		S	0.5	68+	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS
		H	0.55	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS

Key to PSV Table:

(green)	Default IL & PSV
(yellow)	HFS **may** be needed (see notes).

65 (58) = 65 PSV for materials other than TSC (SMA) or 58 PSV for TSC (SMA) surface courses.

Notes on Table 4B

1. **Table 4B** is an amalgamated version of Tables **3.3a & 3.3b from DMRB CD 236**. However, it should be used in conjunction with the Warwickshire "**Highway Skid Resistance Strategy**" (available on the Intranet (internally) or the WCC website (externally).
2. The **Highway Skid Resistance Strategy** states:

   Sites will be defined as Standard (S) risk except in the following circumstances:

   High (H) risk sites:

   • sites where one or more Killed or Seriously Injured (KSI) wet skidding incident has occurred within the preceding three years, OR three or more non-KSI wet skidding incidents have occurred within the preceding three years

   • sites which are on an approach to a hazard (defined as categories Q and K), AND where the speed limit ≥50mph.

   Low (L) risk sites:

   • unclassified roads with a speed limit of 30mph, AND where analysis of accident data has shown that the site is generally less prone to wet skidding accidents

   • sites with no history of wet skidding accidents within the preceding three years.

   This will move many of our sites down to the Low (L) risk category. For new design projects (EDS projects), we should look at historical accident data and combine this with additional safety measures introduced as part of the scheme, i.e. signals, lower speed etc. and make a judgement about risk rating. **This should be recorded as part of the design or technical approval process**.

3. In the table where it states HFS, we should initially surface with 68PSV and monitor the site during the first 12 months to see how it performs. This is justified because you shouldn't lay HFS on new surface course until all the surface binder has been worn/eroded off, leaving the aggregate exposed at the surface. Laying HFS onto new bituminous material will result in very early failure. A SCRIM (or Griptester) test could be done to determine the resulting IL before resorting to HFS. HFS would only be added as a last resort if the IL was low or if there was evidence of wet skidding accidents.
4. When extracting cv/l/d figures from classified counts, this will **not include LGV** numbers, but will include OGV1, OGV2 and PSV totals for a 24-hour period. Many of our counts are for 12 hours and a **1.21 multiplier** is generally accepted to get to 24-hour totals. Remember to take account of roads with multiple lanes and the spread of cv's across those lanes particularly on approach to junctions, and also that the count needs to be for a one direction flow.
5. 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.

6. **HFS** means that high friction surfacing's complying with **MCHW 1 Clause 924** will be required.
7. Investigatory Level (**IL**) is defined in **CD 228** of the DMRB and the "Highway Skid Resistance Strategy".

4.15. All the usual requirements for surface performance, such as **compliance with straightedge** (SHW 701) and finished level must be achieved. In rare cases where texture depth is specified, this should be checked for compliance with the specification given in **Appendix 7/1 of the contract** or the specific **Task Order** for the project.

4.16. Regardless of the type of new surfacing, **ironwork** within the carriageway shall be **reset** to its final level **before the surface course is laid**. In almost every case where ironwork has been reset after laying surface course, the reinstatement has failed prematurely, with those failures occurring in a matter of weeks if the item is in the wheel-track. Care should also be taken to ensure ironwork is laid to the **correct crossfall**. A perfectly level manhole cover or gully set into a cross-falling surface is not satisfactory.

Bridge Deck Surfacing

4.17. Bridge deck surfacing should follow the requirements of **CD 358** (Section 8). The surface course should match (for appearance at least) the surface course used on either side of the bridge, unless when undertaking maintenance work and the existing materials are not able to be matched, i.e. surface dressing or other unsuitable material.

5. Footways and Cycleways (CD 239)

5.1. The footway design should accord with **CD 239** 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.

5.2. **Machine laying** of all bituminous surfacing materials on footways and cycleways is the **default option**. Permission shall be sought from Warwickshire County Council to lay the surfacing by hand. However, it is often the case that maintenance operations better suit hand laying. Small areas, intricate shapes and tying into existing profiles, kerbs and edgings makes machine lay impractical in many cases.

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

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 often poor and is rarely comfortable.

5.5. When a cycleway crosses a kerb line the **kerb must be flush**. There must be no step or upstand between cycleway and footway or cycleway and carriageway where a cyclist is required or even might cross.

Note: Incinerator Bottom Ash Aggregate (IBBA) or any materials containing Incinerator Bottom Ash (IBA) must not be used in the construction of any footway or cycleway.

<u>Surfacing Materials</u>

5.6. Unless the project is on the Trunk Road network, the surfacing material will not be as shown on CD 239 Table 3.18a – 3.18c. On Warwickshire’s network, the **default surfacing material shall be HRA 55/6 surf 100/150pen** when machine laid or HRA 45/6 surf 160/220pen for hand lay (but only in small, narrow or intricate areas, which accounts for quite a lot of maintenance works).

5.7. The specifications for **45% HRA** are given in **clause 970AR**.

5.8. We don’t want to rule out the use of other materials, but any alternative proposals must be provided in good time and with full details of the material including examples of previous use. They must be **dense and durable**

materials with a **proven track record**. Asphaltic concrete, even the dense options will not be accepted. Some of the dense SMA 6mm may be worth trialling, but not at extra cost over HRA 55/6 or 45/6.

5.9. **Modular paving** is generally reserved for **town centre projects** and not a general use option. If used, the choice of product must be **carefully considered**. Matching or selecting themes to maintain or create a “palette” for architectural and aesthetic reasons is perfectly valid, but the **longevity and maintenance liability** needs to be properly investigated prior to making a final decision. The surfacing for **cycleways will be asphalt**.

5.10. Modular paving will, in many cases have a higher maintenance cost and so **commuted sums may be required** as part of the overall justification.

6. Drainage (Surface Water and Foundation)

6.1. This document is not intended to provide design guidance for drainage. However, some key points need to be highlighted to ensure adequate drainage provision is made, as this is one of the most important aspects of delivering long life pavements.

Surface Water Drainage

6.2. Dealing with surface water run-off is an obvious requirement when designing or maintaining a highway. The DMRB provides guidance on drainage design and there are a number of software design packages used to assist with this. There are however a few points to bear in mind.

6.3. Water needs to be **channelled, collected** and **disposed** of safely.

6.4. Where there is a kerb, water flows in the **channel** until it reaches a gully at which point it is collected. The further water travels in the channel the wider the **flow width**. If gullies are spaced too infrequently the flow width becomes too wide, the gullies are overwhelmed, and the road is hazardous. Gully spacing is therefore important and should be designed.

6.5. Where there is no kerb, there still may be gullies, or water may simply drain off the side either via a verge which slopes away from the carriageway or via "**grips**" cut through the verge to a **roadside ditch**. All of these things need to be **adequately maintained**. Grips need to be frequent enough to maintain an **acceptable flow width in wet conditions**.

6.6. **Collection** of water run-off will often be by gully as mentioned in 6.4, or off the side to a roadside ditch as mentioned in 6.5. Alternatively, combined **kerb drainage** may be used. This is particularly useful in areas where there is a **lack of longitudinal fall**. Kerb drainage will usually ensure there is no standing water in the channel. On steeper gradients, it's less effective as the speed of the water flowing in the channel means much of it flows past the openings. This also applies to **kerb offlets** and **offset gullies**. An **offlet gully** or a **gully positioned behind the channel** line (face of kerb) will be **significantly less effective** than a gully positioned in the water flow width. So, replacing gullies in the channel with offlet gullies or offset gullies might be a good idea for removing them from the wheel track on narrow carriageways, but it will mean having a **much closer spacing** which will be a lot of extra work.

6.7. Where kerb drainage systems are used, 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 inevitably occurs when the wheel mounts the kerb.

6.8. **Disposal** of water run-off will generally be by **carrier drain or open ditch**. A number of things affect the design of water carriers, and the details can be found in design standards. Designs must be capable of conveying water into ongoing drainage systems, either Water Company drains, watercourses or rivers. Some designs will require **storage capacity** to allow for intense rainfall to be discharged to ongoing systems in a controlled manner. What should **not be allowed to happen** is for water to **saturate and therefore undermine the pavement structure**. Water ingress due to drainage failure is the single biggest contributor to premature pavement failure in the UK.

Foundation Drainage

6.9. Drainage of a pavement foundation is of **paramount importance** to ensure that the structure and the underlying sub-grade is **not allowed to become saturated**. Water that enters the foundation must have a means of collection and conveyance to the drainage system.

6.10. The **formation layer** surface must be **produced with a fall** to a filter drain to allow water which gets into the structure to run off and be collected. See Highway Construction Details, Highway Cross Sections **A 701.1 – A 701.2** and Edge of Pavement Details **B 701.1 – B 701.2** for layout examples. See also **CD 225 Figures 3.44 & 3.45** as these illustrate clearly how new construction should interface with existing.

7. Adoptable Roads (Section 38's)

7.1. The majority of these are for residential development. The current planning guidance gives different designs depending on the width of carriageway and the use to which the road is put. All designs are for a structural life of 40 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 taxpayers 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. 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:

- 7.3m – this is for large industrial developments and other roads carrying significant numbers of heavy vehicles
- 6.7m – small scale industrial developments, business parks, most bus routes in residential streets
- 6.1m – business parks and bus routes in residential streets; in either case where no demand for on-street car parking is anticipated.
- 5.5m – residential roads serving more than 50 dwellings
- 5.0m – residential roads serving up to 50 dwellings and where the traffic speed is expected to exceed 10mph

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 used. W75 is preferred (which largely self-compacts) up to the underside of the base layer, as this maintains the "W" materials excellent drainage properties across and along the pavement.

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 2 and 3 of this strategy but with increased thickness to allow for the longer design life. From the maintenance viewpoint the bituminous options given in tables 7A – 7B 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 100/150pen binder or for distributer roads on large developments 40/60 may be appropriate. SMA is not usually used as the speed limit is usually 30mph or less, but there might be some cases where it's use may be justified.

7.6. Safety is paramount. As a minimum the Polished Stone Values given in Chapter 4 must be adhered to; care should be taken to ensure that all the higher values needed because of sharp bends and junctions are considered.

7.3 m and wider single carriageways

Table 7A

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

** These wider roads are likely to be major HGV routes or roads serving industrial estates and not just residential. In these instances, a full design will be required in accordance with the guidance in Chapter 3 of this Strategy.*

6.7m and 6.1m wide roads

Table 7B

Layer	**Thickness**	**Material**
Surface Course	40mm	Hot Rolled Asphalt 55/10F surf 100/150 (or 40/60) to BS EN 13108-4 (PD 6691) with a PSV_{60} and AAV_{10} aggregate
Binder course	60mm	AC 20 dense bin 100/150 (or 40/60) recipe mixture to BS EN 13108-1 (PD 6691).
Base	150mm (or 115mm) Minimum*	AC 32 dense base 100/150 (or 40/60) recipe mixture to BS EN 13108-1 (PD 6691)

* *As above, it may be deemed appropriate to carry out a pavement design in accordance with the guidance in Chapter 3 of this Strategy.*

5.5 m wide and narrower roads and areas with shared use

Table 7C

Layer	**Thickness**	**Material**
Surface Course	40 mm	Hot Rolled Asphalt 55/10F surf 100/150 (or 40/60) 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 (or 40/60) recipe mixture to BS EN 13108-1 (PD 6691).
Base	125 mm (or 100mm)	AC 32 dense base 100/150 (or 40/60) recipe mixture to BS EN 13108-1 (PD 6691)

Note: In the tables above, the figure for base thickness in brackets is if 40/60pen binder grade is used.

7.7. Segmental paving may be permitted for these roads with the following provisos: only rectangular pavers 200mm x 100mm and 80mm 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 will ensure rapid failure as the sand can no longer support the traffic loads. The minimum requirement for draining the sand is to drill 30mm holes through the asphalt layers at 1000mm centres in each direction. These core holes shall be filled with 2.36/6mm single size chippings and a pad of geotextile fixed over the top prior to spreading the bedding sand. The geotextile shall have a pore size of 90µm (±5). 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 re-laid 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 previously are used a high commuted sum would be required.

7.8. 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 DMRB CD 239, 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.

7.9. The construction shall be as shown in **Table 7D**.

Table 7D

Layer	Thickness	Material
Surface Course	110mm	80mm thick pavers on 30mm sand bed
Base/binder course	160mm	AC 20 dense bin 100/150 (or 40/60) recipe mixture to BS EN 13108-1 (PD 6691) laid in two layers. Perforated as described in note below.

Note: 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 30mm holes through the asphalt layer at 1000mm centres in each direction. These core holes shall be filled with 2.36/6mm single size chippings and a pad of geotextile fixed over the top prior to spreading the bedding sand. The geotextile shall have a pore size of 90µm (±5).

Footways and cycleways

7.10. Footways shall be constructed in accordance with **Table 7E** which consists of appropriate extracts from CD 239 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, e.g. 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, wheelchairs 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.

7.11. 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 7E - footway and cycleway construction

<table>
<tr><th colspan="4">Footways and cycleways in residential areas</th></tr>
<tr><td>Surface course</td><td colspan="2">25mm thick Hot Rolled Asphalt 55/6F surf 100/150 to BS EN 13108-4 (PD 6691)[1] with a PSV_{50} and AAV_{10} aggregate</td><td>65mm thick pavers[3] or 400mm x 400mm slabs or mix all with a PPV of 50 minimum on a well drained 30mm sand bed</td></tr>
<tr><td>Binder course</td><td colspan="2">75m AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691)</td><td>60mm AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691)</td></tr>
<tr><th colspan="4">Sub-base</th></tr>
<tr><td>CBR of subgrade</td><td>≤ 2½%</td><td>2½ - 5%</td><td>> 5% (rare in Warwickshire)</td></tr>
<tr><td>Sub-base thickness[2]</td><td>*250mm</td><td>200mm</td><td>150mm</td></tr>
<tr><th colspan="4">Footways and cycleways in industrial and other non-residential areas</th></tr>
<tr><td>Surface course</td><td colspan="2">25mm thick Hot Rolled Asphalt 55/6F surf 100/150 to BS EN 13108-4 (PD 6691) [1] with a PSV_{50} and AAV_{10} aggregate</td><td>80mm thick concrete pavers[3] with a PPV of 50 minimum on a well drained 30mm sand bed</td></tr>
<tr><td>Binder course</td><td colspan="2">100mm AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691)</td><td>100mm AC 20 dense bin 100/150 recipe mixture to BS EN 13108-1 (PD 6691)</td></tr>
<tr><th colspan="4">Sub-base</th></tr>
<tr><td>CBR of subgrade</td><td>≤ 2½%</td><td>2½ - 5%</td><td>> 5% (rare in Warwickshire)</td></tr>
<tr><td>Sub-base thickness[2]</td><td>*365mm</td><td>250mm</td><td>200mm</td></tr>
</table>

** Further geotechnical measures may be needed.*

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.

Note 2: Where the sub-grade is frost susceptible the sub-base thickness shall be increased to bring the total construction thickness to 450mm. Where the sub-base thickness is above 200mm a combination of W75 with type 1 or type 3 may be used. (Road planings to type 4 and containing at least 80% bituminous materials may be 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: Where it’s not possible or practical to machine lay and so hand laying of bituminous materials in footways is required, the binder grade may be changed to 160/220pen.

7.12. When rural footpaths (rights of way) are to be included or upgraded as part of a development, the appropriate Warwickshire Rights of Way officer must be consulted. It is not always appropriate to pave such rights of way as maintenance liability may not be a simple matter. The intended usage or change of use will have a bearing on the choice of materials used and style of route provided.

7.13 As stated in other chapters of this document, materials containing **Incinerator Bottom Ash (IBA) including IBAA are not permitted** in carriageway or other paved area's to be adopted by the Highway Authority.

8. Highway Maintenance

8.1. Warwickshire County Council is responsible for around 4,000km of highway, with an asset value approaching £8 billion. An efficient maintenance regime is essential in order to take proper care of this crucial asset.

8.2. Not only must the highway network be maintained for its **strategic use**, but it must also be kept **safe for all users**. As well as the human cost, the cost to the economy of serious accidents is staggering and Warwickshire has an excellent record of reducing accident figures, particularly over the past 20 years. A well-maintained network is often a safe network.

<u>Data Sources</u>

8.3. There are several sources of data that can be used to assess maintenance needs and also in the design of maintenance treatments. It is recommended that as many of these (listed below) are utilised as possible, as this provides the best chance of providing a solution which resolves more than just the basic need to repair damage. For example, when deciding on a resurfacing option, collision data may reveal a cluster of accidents which could be resolved with increased PSV of aggregate, changes to road markings or drainage improvements. A broad approach should be taken to the design of maintenance projects.

Sources of data include:

- SCANNER
- Course Visual Inspection (CVI)
- SCRIM
- Serviceability Inspections
- Collision Data (using Compass)
- Information from the public
- Traffic flows
- Records of historic maintenance treatments
- Trial holes
- Investigatory cores
- Tar testing
- CBR tests
- DMRB, particularly sections mentioned in chapters 2 - 5 of this document
- This document
- Advice from Road Safety Team
- As built drawings from major projects

8.4. In addition to the previous list, there is a lot to be said for **knowledge and experience of the Highway Maintenance Engineer**. The ability to look at a failing road and be able to identify the surface material from its appearance, the mode of failure, make a good guess of the structure of the road and come up with a treatment proposal without any other information, is a skill that comes with experience. An experienced engineer will then go back to the office and check all those other data sources to **confirm or refine** his treatment proposal.

8.5. When full construction is required the guidance given in Chapter 2 of this document should be followed to determine the foundation design. **Capping thickness, formation crossfall and drainage of foundation** must be **properly designed**.

Maintenance Options

8.6. 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.

8.7. Warwickshire has developed a knowledge of its road network over many years which has led to a maintenance regime and a **catalogue of materials and treatments that are tried and tested**.

8.8. The **DMRB** also provides guidance in **CD 227** which may be a useful reference in some cases. Some of Warwickshire's road network was once Trunk Road and hence CD 227 could have particular relevance to those. Also, whilst we do not have many concrete roads in Warwickshire, there are some and CD 227 designs may prove to be the way forward.

8.9. **Good records** of maintenance treatments are also important as they provide knowledge of how long different treatments last in different situations. They also provide information for future designs.

8.10. **Table 8A** shows a range of maintenance treatments and provides information about each, to enable Engineers to assess various options suitability for a given situation. This table has been updated from previous versions based on more recent knowledge and experience. Sadly, treatment life expectancies have been reduced for some treatments. This may be due to the use of less durable materials or poorer workmanship in some cases, but it's also likely due to increasing traffic levels.

Table 8A

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 (only)	Any	No	No	No	No	No	Very high	Slow	No	No	0 - 3	-- 4 to -- 2
Retexturing	0	No	1.2	Yes - short term	No	No	Low to Medium	Fast	No	No	2 - 3	+ 3 to + 4
Surface dressing	6-14	No	1 - 3	Yes	Yes (best)	No	Low	Fast	No	No	5 - 12	+ 2 to +4
Slurry surfacing	6-15	No	0.5 - 1.5	Yes	A bit	Can do	Medium	Fairly fast	Slight	No	5 +	+ 2
SMA surfacing	20-70	Yes	0.5 - 2	Yes	Usually	Yes	Medium	Moderate	Yes	Yes	15+ at 4% void. 8 at 8%	+ 3
55% hot rolled asphalt	35-70	Yes	0.3 - 1	Yes	Yes	Yes	Medium	Moderate	Yes	Yes	10 - 15	+ 3
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	2 - 10	-- 5
Structural overlay	80+	Yes	Depends on S/C	Yes	Yes	Yes	High	Slow (to moderate)	Yes	Depends on S/C	20+ for structure	+ 4
Haunching /strip widening	80+	Yes, locally	Depends on S/C	Depends on S/C	Yes	Yes	Medium to high	Slow (to moderate)	Yes	Depends on S/C	20+ for structure	--2 to + 2
Retread (SD twice)	75-100	Yes	About 1	Yes	Yes	Yes	High	Fairly fast	Yes	No	10+ (as structure)	+ 3
Deep recycle with foamed bitumen	150-250	Yes	Depends on S/C	Depends on S/C	Yes	Yes	Very high	Slow	Yes	Depends on S/C	20+ for structure	+ 4

8.11. From **Table 8A**, a **combination of treatments** is often a good way to provide a **long-life solution** and hence move the combination to a more cost effective and sustainable option. For example, **haunching** or strip widening combined with an **overlay** provides a **more complete solution** and whilst costing more initially, the long-term cost is reduced and the disruption is reduced by completing all the work in one visit and hence one TM set up, one TTRO, one phase of mobilisation and one round of plant & equipment deliveries.

Materials

8.12. See Chapters 2–5 which are relevant to highway maintenance. However, for maintenance more variations and options are and should be considered as can be seen from **Table 8A**. Some specific guidance follows.

8.13. **Capping** material for highway maintenance will always be **W150 or W75**. These Warwickshire specific highly permeable materials are known to be very strong and highly tolerant of being waterlogged and so provide a **guaranteed best option**.

8.14. **Sub-Base** shall be as per Chapter 2 of this document. The **default** option is **Type 1**, but type 3 or type 4 are alternatives. Type 2 is not recommended as it's comparatively fine graded. If type 4 (asphalt planings) can be used from the site, this would be an ideal situation. **Incinerator Bottom Ash (IBA) including IBAA is not permitted.**

8.15. **Base** and **binder course** material should default to **AC 32 dense base recipe mixture and AC 20 dense bin recipe mixture** and generally using **100/150pen** binder grade. For significant projects on major roads, 40/60pen binder grade may be more appropriate, however it should be noted that there is no point using a harder binder for an overlay on top of softer binder. Existing road materials can be tested to determine the approximate binder grade, so that consistency can be maintained. **Other options** may be appropriate in some instances, such as hot rolled asphalt base and binder which can prove to be flexible and crack resistant, perhaps when laying over lean mix concrete base. SMA binder may also be an option if demonstrated to have a particular advantage.

8.16. **Surface course** again should default to the options given in Chapter 4 of this document. The most widely used option being **HRA 55/10 with 100/150pen** binder grade. 40/60pen may be used but see 8.15. **SMA 10** surface course is the other main option. See Chapter 4 para. 4.4 for details. The **high-performance binder option**, whilst expensive has been found to be impressively **resistant to crack transmission**. **Hot rolled asphalt with chippings** fell out of favour a couple of decades ago but is beginning to see a **resurgence**. When laid well (not in winter) on an appropriate road, this can prove to be a **highly durable surface course**. There may be a high initial cost compared to the other options, so it must only be used on a more major route which is **known** to be **structurally sound**. See also Chapter 9 in relation to material trials. HRA 55/14 has also been used in the past to afford a thicker overlay in a single layer. The appearance was sometimes variable, with some more open textured patches, which may have been due to segregation during transportation. This material should probably be tried again as it did have potential at a reasonable cost.

8.17. **Bond coat** must be correctly applied between **all bituminous layers**. See Chapter 3, para. 3.7 for more information.

Treatments (Carriageway)

8.18. **Overlay** as the name suggests consists of overlaying the existing pavement with one or more layers of new bituminous material. It adds strength and hence life to the pavement, restores ride quality and skid resistance. **Do not overlay a badly failed section** of pavement as that weakened section will fail prematurely again in the future. Having said that, if a suitably thick overlay can be applied, to the extent that the existing pavement can be considered the equivalent of sub-base only, this may be acceptable. In such instances, the **drainage** of the pavement foundation should be **investigated** as this may well be the cause of failure. For overlays, interface with thresholds may be a limiting factor.

8.19. **Inlay, plane/resurface** is suitable where the existing surface level needs to be maintained. It may not add a lot of strength if only the surface course is replaced but planning deeper to replace old failed materials with modern ones will be a good improvement. It might be appropriate to specify premium materials in such projects such as the SMA with premium binder, to maximise the increase in durability achieved.

8.20. **Haunching/strip widening** is a good option where failures are confined to the haunch of the road (the 1st quarter from the edge). Haunching may and strip widening will include full construction depth including capping, so **ensure the foundation can drain**, see Chapter 6. Haunching may only involve planning and renewing failed bituminous material. If so **investigation of drainage** should be carried out as this may be a contributor to the failure. **Stepping of joints** in the different layers should be adhered to, otherwise there is a good chance that water will enter the pavement and the structure will quickly crack at the vertical joint, see **Highway Construction Detail B 705.1**. On rural sites where **no kerb** is to be provided, the pavement structure should **extend beyond the carriageway edge** at an angle not less than 45º equivalent to what is shown on drawing **B 705.1** but including the bituminous layers. The best haunching projects also include an overlay, which provides a uniform surface and seals the whole structure.

8.21. **Surface Dressing** is capable of doing two things, **sealing** the surface and improving **skid resistance**. It's a relatively cheap and a quick process to carry out. It's ideal for use where skid resistance has been shown to be sub-standard, either by **SCRIM** testing or **collision investigation**, as long as the pavement is basically sound. It's also used to extend the life of a pavement where the surface course is close to the end of its life and starting to show signs of distress. **It will do little to help a failed road**. Pre-patching will often be needed if there are isolated surface defects such as potholes, fretting or failures around ironwork. If a **lot a pre-patching** is required, then this would suggest the road has **been left too long** and that surface dressing is probably **not the appropriate treatment**. History has demonstrated to us that use of an **excellent binder** and good **clean chippings**, plus carrying out the work at the **correct time of year** in ideal conditions is the **key to successful** surface dressing. If any one of those things is not in place, failures can be expected.

8.22. **Retread** is a type of shallow in-situ recycling. The depth of the treatment is typically **75mm -100mm**. The existing pavement is broken up in-situ using a planer, often additional aggregate is added and harrowed to mix it in, regraded, **sprayed with bitumen emulsion** and rolled. A 6mm **surface dressing** is laid on top to seal the pavement and provide a running surface. It's best used on lightly trafficked and thinly constructed roads, either residential or rural. It tends to be **not particularly dense** and probably fairly high voids but does often remain flexible enough to cope with some ground movement or continued compaction under traffic. **Ideally** retread should be **overlaid** with an asphalt surface course, either as part of the same project or the following year. As a minimum, a second surface dressing should be accounted for.

8.23. **Deep In-situ Recycling** is a much more involved and disruptive process. It involves a similar process to retread, but to depths of **150mm – 250mm** and involves much bigger machinery. It's also **expensive** and this is probably one reason it's not been used very often in Warwickshire. Deep recycling usually involves removing some material to allow new surface course and sometimes also binder course to top the pavement. The only site the author knows this to have been done, is the B4098 in Fillongley, north Warwickshire in the late 1980's or early 90's. It is still sound today.

8.24. **Patching** is an inevitable tool for road maintenance. The word patching covers a multitude of options. At its most basic, patching could be just **filling a pothole** with some cold lay bituminous material. This is often called "cow patching" and is only a **temporary measure** to make safe. It's not unusual to revisit a temporary patch several times until a permanent repair is scheduled. Be aware that the **public** generally **cannot grasp this principle**. Beyond the temporary fix, **patching** should be intended as a **permanent repair or a repair prior to another treatment** such as surface dressing or overlay. Some obvious but often overlooked points to note are:

- A surface course patch is **pointless** where there is structural failure;

- A patch needs to include **all** the damaged area. A “permanent” patch of a pothole in a larger area of failed pavement is a waste of time and money. **Include the whole area**.
- **Workmanship** is very important. A neatly cut out area, clean surfaces, bond coated surfaces and faces, no standing water, hot material and good compaction are all a must.
- **Overbanding**, which was withdrawn a number of years ago, has moved on a lot and would be beneficial to reintroduce and indeed has been to a degree. **Only HAPAS** approved products may be used as these have proven performance credentials and safely characteristics.
- For patches involving multiple layers, the layers should be **stepped** by at least 75mm (the full spec. 300mm is generally impractical).
- For deep structural patches, it’s logical to use surface course in multiple layers unless it’s a large area in which case AC 20 dense binder could be used for all but the surface layer. **Bond coat** should be applied **between all layers**.

8.25. **Miroasphalt (Microsurfacing/Slurry Surfacing)** is an option that falls between surface dressing and resurfacing or overlay. As the name suggests it is laid thinly as a bituminous slurry. It is capable of a degree of ride quality improvement, improving skid resistance and sealing the surface. It doesn’t add much if any strength but is relatively quick. It does have some drawbacks noted from past projects, such as the need to reset ironwork after the slurry process, due to difficulty in predicting final level. This has resulted in some failures around chamber covers. Also, the slurry takes time to “break” (set) and it’s very difficult to ensure nobody will drive or walk on it before this happens. There have been claims for cleaning of private cars and carpets.

Treatments (Footways/cycleways)

8.26. **Reconstruction** is suitable where complete structural failure has occurred or where widening is to be included. See Chapter 5 for guidance.

8.27. **Resurface** is a widely used option but will usually involve replacing all the blacktop. The project engineer needs to be confident that the footway/cycleway **foundation is sound** and is suitable to construct on it. It’s sometimes possible to replace just the surface course on large areas where there is sufficient width and space in general to allow plant movements, particularly the planer. The other consideration is whether the weight of the plant could damage the structure. In **most cases** for maintenance work, the **surface course and binder course** are excavated and removed with **2 new layers laid**. It might be that some type 1 regulating is needed prior to laying the binder course.

8.28. **Slurry Seal** is a relatively cheap and quick process which has become widely used in Warwickshire. As the name suggests this is a hand laid product of the type described in para. 8.25. It is capable of a degree of improvement to surface regularity and is also good to seal the surface and provide good slip resistance.

8.29. Other treatments are available such as surface dressing or overlay but are rarely used as it's not often practical. There may be other things to try, but if done as a trial, must be recorded and monitored for future reference.

<u>Other Maintenance Liabilities</u>

8.30. **High Friction Surfacing (HFS)** is rarely used in Warwickshire, but there are some sites where this is in place. In some cases, this can legitimately be replaced with a surface course with a high PSV, but great care must be taken when making this decision. HFS is the only way to achieve PSV values over 70 and there are cases where this is necessary. **See Chapter 4, Table 4B**.

8.31. **Coloured surfacing** is also quite rare in Warwickshire because historically some of the products have lacked durability or have not retained their colour, as well as being expensive. Some of the modern materials are much better and using **coloured aggregates and pigmented binder** they can be durable and able to retain colour. They are still **expensive** though, hence often a **commuted sum** will be a requirement where they are installed. More recently these materials have been used in town centre enhancement projects to help to differentiate a different street scene. Resin based surface treatments can be coloured and may be used both as a HFS and to introduce a colour. HFS often uses **calcined bauxite** as its aggregate, which is **not an environmentally friendly product**, so should be avoided if at all possible. If just a colour is needed, high PSV aggregate is not required. These surface treatments can have short lives, which is why we try to avoid them. Surface dressing using selected coloured aggregate has been used in the County and was proved to work well. **Table 8B** shows some options for different natural aggregates which may be available.

Table 8B - Summary of coloured aggregates

Colour	Source	PSV	Comments
Green	Criggion, Shropshire	60*	This aggregate was 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.*

9. General

Material Trials

9.1. Warwickshire has been enthusiastic about investigating better ways of doing things since at least the 1960's. We've worked with suppliers to develop new materials and have always been open to trailing materials and processes, as long as they **stand up to scrutiny**.

9.2. Some examples of materials and processes that have been trialled and then more widely used in the County are summarised below:

- 1978 - Medium temperature asphalt (55/10F) was first laid in Warwickshire 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.
- 1994 - Some of the first trials of thin surface course took place in Warwickshire in 1994 and are now in frequent use Countrywide.
- 2004 - Use of Tarmac's Masterflex which is a 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. This is now Ultipave.
- 2013 - 55/6-14F (Hybrid) is a replacement for 55/10F but uses very little 10 mm aggregate, which is generally in high demand. This has potential for use more widely.
- 2020 – Structural Material for Reinstatement (SMR) recycled base for footway, trialled at Hatton and being monitored at the time of writing.

9.3. Material trials should continue to be embraced into the future, but care should be taken to select materials and processes that are realistically **likely to provide some benefit over what we already have**, or to **solve a particular problem**. A material that performs the same task as one we already use, without any evidence that it performs better, would need to be cheaper or more sustainable to warrant a trial.

9.4. **Trials** must be done in a **scientific manner.** Good records of a trial should be maintained for **several years** to monitor the performance over a long period. Trials using two or more materials on the same section of road are a good way to compare a new material with one we already have experience of.

9.5. Introduction of different materials or processes for maintenance may be **difficult in the middle of a Term Maintenance Contract** as the pricing will not be as competitive as the original tender. However, this should **not stop trials** taking place as it still might be possible to bring something into a current contract, but if not, it could be included in the next contract.

9.6. Something that should be **considered** is the **systematic study of materials, processes and treatments** we do have and see which of them suffer the most failures. This information can then be used to set up **focused trials** to see how these treatments could be **done better**. The results could lead to immediate implementation of different methods or materials or fed into the next Highway Maintenance Contract.

Sustainability

9.7. There has been a steady shift over the past 20 years to make the construction industry more sustainable. In Warwickshire, **sustainability** has been at the heart of what we do for many years. The first use of W150 in the 1960's was instigated to allow crushed concrete from two local WW2 airfields, to be used as permeable capping (lower sub-base) on the Warwick Bypass (now A46).

9.8. We have always tried to build and maintain **long-life pavements**, reusing existing structure wherever possible, minimising waste and using durable materials and designs. This must continue.

9.9. Use of **recycled or secondary aggregates** should always be **considered** where a local source is available, as long as it **doesn't compromise** on durability. Exercise caution as there are some poor materials that rely on the sustainability badge for marketing. **Premature failure is not sustainable**.

9.10. The latest version of the **DMRB** opens up more options for pavement foundation and structural layers and there may be scope within it to try some new things in Warwickshire, though probably only for large projects.

9.11. This new 2021 County Road Construction Strategy introduces some options which provide additional scope for savings in raw materials and disposal, such as use of 40/60pen binder, which reduces pavement thickness and pavement foundation designs aligned with DMRB for large projects.

9.12. In Warwickshire **sustainability** has always been **intrinsically linked to durability**. There is **always scope to improve durability** and this must be the aspiration. The sustainability cost of multiple visits to a defect or premature failure of a pavement is not just about the financial cost, the wasted materials and extra waste to landfill, it's also about wasted fuel for transport and the pollution that it causes.

10. Annexes

Annex A - Guide to Supervising Surfacing Work
Annex B – W150 and W75 Sub-bases
Annex C – Surfacing Capabilities
Annex D – Summary of Factors Affecting Skidding Resistance
Annex E – Other Documents Recommended as Sources of Information

Annex A Guide to Supervising Surfacing Work

1. Introduction

1.1. The surfacing element of any project is one of the most important, because it's an expensive operation, it's likely to involve the most disruptive traffic management and it's something everyone is going to notice, good or bad. So, it's worth making every effort to get it right first time.

2. Before the Surfacing Operation

2.1. The obvious thing to check is the line and level of the surface to be overlaid. This may be sub-base material or a previous bituminous layer. The contractor should "dip" this underlying surface to ensure its within specified tolerance and also to identify where any additional regulating needs to be done. **See BS 594987 Paragraph 5.2** for tolerances. You need to be familiar with the technique of "dipping".

2.2. If planing is required, it's worth looking at this at an early stage. The depth of planing will be specified, say 40mm deep, but the old surface course might have been surface dressed or the surface layer may be more than 40mm, which could result in a thin lens of material being left behind which may not be well bonded to what's beneath. If this is the case the contractor should increase the planing depth to remove the loose material. Ideally, cores or trial holes will have been taken beforehand to determine, amongst other things, the existing layer thicknesses, in order to pre-empt this issue and specify the planning and resurfacing appropriately in the contract and hence minimise the risk of Compensation Events.

2.3. As part of the pre-surface course paving checks, it is worth checking the levels of ironwork within the area to be paved. This can and should be done as part of the dipping process. Ironwork needs to accurately match what will be the new surface level and be set to the **correct cross-fall** to match the road at that point.

2.4. The surface to be overlaid must be clean and free from loose material, mud and other detritus. The contractor should provide a mechanical sweeper, particularly if planing has been done.

2.5. **Bond coat** is the next important consideration. This is still often referred to as tack coat, but we should try to avoid this as tack coats no longer comply with the specification. Bond coat should be applied by a proper spray bar, usually from a large tanker. Spraying using a hand lance is not permitted, except in very small and inaccessible places where it isn't possible to reach with the tanker.

2.6. Bond coats are polymer modified and the product to be used should be proposed by the contractor and approved by the client at an early stage. See contract **Appendix 7/4 and Specification Clause 920**. You may want to look at the driver's delivery ticket to confirm that the material on board is what has been agreed.

2.7. Bond coat shall be applied between all bituminous layers. This is without exception, regardless of whether the previous layer was laid last week, yesterday or an hour ago.

2.8. All vertical faces to which the new surface material is to be laid, must be painted with bitumen to ensure a good bond and seal. This means all ironwork, kerbs and existing asphalt faces.

2.9. The weather is another important consideration. Cold, wet and/or windy conditions may be grounds for surfacing work to be suspended or postponed. As a general rule, wet weather may not be a problem, but standing water is. A torrential downpour should result in suspending work temporarily, keeping material in the waggons covered and waiting till it passes. If very bad weather is forecast, the contractor should decide in advance to postpone the work. There should never be material laid in standing water. It might be possible to use the vacuum sweeper to remove small areas of standing water to allow work to continue. Cold weather is the other obvious problem, particularly if there is also a wind chill. Again, the contractor should be looking ahead during wintertime, to decide whether to postpone works if the forecast is unfavourable. **See BS 594987 section 6.2** for direction on this.

3. Laying Blacktop

3.1. It's up to the contractor to calculate order tonnages for materials to lay a particular area, but you might want to have a double check at an early stage. If you roughly base calculations on 2.2 t/m³ for the base layer and 2.35 t/m³ for binder and surface course, you should be somewhere close. So, for 3000m² of surfacing at 40mm thick they should order something like 3000 x 0.04 x 2.35 = 282 tonne + a bit for regulating and to be sure. Contractors have been known to run out of material 3m from the end of a job.

3.2. **Do look at material delivery tickets** which will show what material is on board the wagon. Try to look at one as early as possible, because if it's wrong there is a better chance to deal with the problem before they start laying. The material specification will be given in **Appendix 7/1** of the contract, and you should make sure that what is on site is the correct specification. You need to be familiar with how materials are described as the ticket will generally show the coded description. So, it will say something like "AC 20 dense bin 100/150pen" which is dense binder course with 20mm aggregate and 125pen binder. For surface courses the PSV should also be shown.

3.3. If the material specified on the ticket is not correct you should notify the contractor immediately that the material doesn't comply with the contract specification. If they have or do lay material of the wrong specification it will usually need to be planed out and replaced.

3.4. **Material temperature** is another key factor for successful surfacing. There are key points where temperature can and should be checked; delivery temperature and rolling temperature. These can be found in **BS 594987, Annex A, Table A.1** for a range of materials.

3.5. Temperature can best be checked using a "blacktop thermometer" which has a metal probe connected to a digital thermometer. We have such devices which can be booked out from our equipment store. It goes without saying that bituminous material, during the surfacing operation, can be very hot and very sticky so **do not touch it, wear gloves**. Also, do not walk on it unless you have **heat resistant soled boots**.

3.6. It is worth understanding how a paving machine works as this will help you understand what is and isn't possible, both at the design stage of a project and when supervising the work. There are a few fundamental things to note about a paving machine. The paving machine's vibrating screed essentially floats along on a cushion of material. The level at which the screed floats and hence the thickness of material laid will depend on the material being laid (viscosity) and on the screeds "angle of attack", which is controlled by hydraulic rams on the sides of the machine. Raising the rams, lifts the control arms and increases the angle of attack which makes the screed float higher and increases laying thickness. This doesn't happen instantly and in fact is likely to take more than a paver length to take full effect. This is important, because if you are laying against an existing surface or kerb, which is undulating, you will probably not get levels to match properly. Hand raking can help with this, but lots of raking often leaves a less than perfect finish. Some materials (SMA's for example) really do not respond well to raking.

3.7. When laying in 2 or more rips, the edge of an unsupported rip should be cut back and the neat newly cut face painted with bitumen. This is because an unsupported edge tends to push out under the load of the roller and hence receives incomplete compaction and usually leaves a jagged and cracked edge. Cutting back isn't necessary if the 2 rips are to be "hot matched", i.e. when short sections are laid, and the second rip is laid against the first before rolling. This might be the case on short sections, roundabouts or junctions. **See BS 594987 Section 6.8** for full guidance.

3.8. To back up any checking you've done with dips, you can check the laid material thickness by pushing in a thin rod (the thermometer probe might be suitable if sturdy enough) and measuring the depth of penetration to the layer below. **Do wear gloves** as the material will be hot and sticky. Remember there should be a surcharge to allow for compaction, which will probably be about 15%. Don't attempt this after compaction!

3.9. The other thing to look out for is debris falling into the mat or onto the road in front of the paver. For example, tree branches if snagged by the delivery waggon, crisp packets, drinks cans, leaves and work gloves are all common contaminants. The paving gang may or may not notice these things so do point them out to the foremen and ensure they are removed.

3.10. Compaction is key to the durability of bituminous material and hence is of paramount importance. All materials we specify have a compaction specification based on % voids of the completed layer, see **Contract Appendix 973 AR**. The contractor will often monitor compaction using an Indirect Density Gauge which should help to ensure all area's receive adequate compaction, but they are not fool proof. If there are roller marks in the surface, it's a good indication that full compaction has not been achieved. Pay attention to more intricate area's where the roller may struggle to reach properly. Other forms of compaction can be applied such as a smaller roller, whacker plate or even a hand tamp in these areas.

3.11. Another thing to check as the work progresses is how the contractor is matching into ironwork. The ironwork levels should have been checked already so the surfacing contractor must lay accurately to them. Laying to gully gratings, in particular, must be done accurately to avoid ending up with embarrassing standing water. There is a tendency for contractors to realise they are a few millimetres low on the approach and then lay up to the gully leaving standing water on one or both sides of the gully, or to approach a few millimetres too high and then lay down to the gully. Both of these mistakes also lead to an uncomfortable undulating channel line.

4. Opening to traffic

4.1. There will need to be an interval between completing the compaction and opening to traffic to allow the surface to cool down sufficiently so that traffic will not cause rutting or surface damage. The time needed is highly variable depending on the weather conditions. On a hot summer's day, it is recommended that the lane not be opened for 24 hours, on a cold and or wet day it may be less than an hour. See **BS 594987 Section 10** for guidance.

5. General

5.1. When on site to supervise bituminous surfacing work it's a good idea to have a copy of **BS 594987** with you. It's not a big document and it's easy to find key advice using the section headings. It seems in recent years that even the well-known specialist contractors do not know the specification and are frequently surprised and argumentative when we ask them to comply. Having **BS 594987** with you is useful to point out the appropriate paragraph when the foreman is debating having to bond coat every layer despite only having laid the previous layer the day before, or about having to paint the kerbs and ironwork.

Annex B W150 and W75 sub-base

1.1 The aim, when this specification was introduced, was 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. In recent years though, little if any use of recycled material to this specification has been used. It seems that nowadays, the production of the W materials is a specific and separate operation at our local quarries.

1.2 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 1: Although the main sieve size is now 125mm 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 2: For explanation and definition of 'D' and 'd' see PD 6682-2

Note 3: For recycled materials the simplest way of obtaining W75 is to set the crusher at about 90mm and screen the crushed material on a 20mm 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

1.3 The first use in Warwickshire of open graded sub-bases was on Warwick Bypass which was built between 1965 and 1967. 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" (115mm) and the resultant crushed material screened over a ¾" (20mm) 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.

1.4 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 150mm (and even larger material was used when reconstructing the M6).

1.5 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=1m/sec approximately. The intention at all times was 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.

1.6 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.

1.7 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. The open graded Warwickshire sub-bases have over the years been shown to remain adequately 'strong' under any moisture regime. Research at Nottingham University has shown that open graded unbound materials are stiffer than 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 200mm; 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.

1.8 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-bases do not suffer from pore water pressures and aggregate interlock remains good even under water. Therefore, they are fairly tolerant of poorer drainage maintenance.

Annex C Surfacing Capabilities

Waterproofing the pavement structure

1.1 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 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 in their binder emulsion to escape when they "break", although they become significantly less permeable with time. Porous asphalts by their nature are very permeable.

1.2 When surfacing or resurfacing, the stepping of joints is another key requirement for keeping water out of the pavement structure.

1.3 As mentioned in 1.1 above, proper bond coating between all layers also has a role to play in waterproofing a pavement, as well as providing adequate bond between layers.

Adding strength to the pavement

1.4 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 surfacings should be ignored.

1.5 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 (e.g. Ultiflex) may be used. As an alternative a binder course plus surfacing combination may be used.

Improving ride quality

1.6 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

1.7 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 Highway Engineer but can be designed for. Site layout is changeable in the long term but is an expensive option. In 30mph 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]

Other factors

1.8 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 environmentally 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 matched colour.

- Time of year – some surfacings cannot be laid in winter – e.g. 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 for lightly trafficked roads and those with a 30mph 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 30mph speed limit is routinely exceeded. Thin surface courses can provide good noise reduction on higher speed roads. Noise reducing properties of individual products are published on HAPAS data sheets or can be obtained from producers. 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.

Annex D Summary of factors affecting skid resistance

1.1 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.

1.2 The major ones with an estimate of their potential relative effect on skid resistance is given in Table D1

Table D1 Relative effect on skid resistance of various factors

Factor	**% change in SCRIM coefficient from highest to lowest**	**Notes**
Time of year	15 or more	Skidding resistance is lowest in mid to late summer. Weathering in winter, polishing in summer
Aggregate size	20	3mm highest skidding resistance, 14mm and 20mm lowest skidding resistance.
Change of skidding resistance with speed on low textured surfaces e.g. 55/10 asphalt	9 (locked wheel) the effect is less with rolling wheel	Drop in skidding resistance from 30mph to 60mph. Below 30mph skidding resistance increases with low texture*
Change of skidding resistance with speed on high textured surfaces e.g. racked in surface dressing	2 (locked wheel) no effect with rolling wheel	Drop in skidding resistance from 30mph to 60mph
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)

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

Annex E Other Documents Recommended as Sources of Information

Design Manual for Roads and Bridges (DMRB) – Easily accessible on-line, this contains the national design standards for Trunk Roads, but is applicable at least in part to all roads.

Specification for Highways (SHW) – As above.

BS594987 – This is available to WCC staff via our subscription to the IHS Website. This standard covers all things to do with bituminous materials. It contains most of what you need to know about producing and laying bituminous materials.

TRRL Report LR1132 The Structural Design of Bituminous Roads – This document dates back to 1984 but is still the most comprehensive study of pavement design done in the UK. This document is still referenced in the latest version of the DMRB and is also the basis for portions of this document.

Road Note 42 (TRL) Best Practice Guide for Durability of Asphalt Pavements – First published in 2008 this is a mine of information and advice which underpins Warwickshire's aim to build and maintain long life pavements.

Specification for the Reinstatement of Openings in Highways (DfT) 2020 – This is exactly what the title suggests and is quite new as I write this. It's a long document and describes what should happen, but probably doesn't very often.

Well-Managed Highway Infrastructure, a Code of Practice (2016) – This document published in 2016 replaced the old "Well Maintained Highways – Code of Practice for Highway Maintenance Management" and provides a more modern risk-based approach.