VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE

SECTION 5 SURFACING AND SURFACING MATERIALS

PART 1

HD 36/99

SURFACING MATERIALS FOR NEW AND MAINTENANCE CONSTRUCTION

SUMMARY

This standard provides a summary of surfacing options available for use on both flexible and rigid pavements and advises on current requirements for surfacing. It also details requirements for aggregates previously covered in HD 28 (DMRB 7.3.1) and gives advice on surface texture.

INSTRUCTIONS FOR USE

This is a new document to be inserted into the manual.

1. Insert HD 36/99 into Volume 7 Section 5 Part 1.

2. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

THE HIGHWAYS AGENCY

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
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THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

Surfacing Materials for New and Maintenance Construction

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SURFACING MATERIALS FOR NEW AND MAINTENANCE CONSTRUCTION

Contents

1. INTRODUCTION

1.1 This Part provides a summary of surfacing options available for use on both flexible and rigid pavements and advises on current requirements for surfacings. The Part also details the requirements for aggregates to ensure that satisfactory skidding resistance is provided on roads, this topic was previously covered in HD 28 (DMRB 7.3.1). This Part also includes details of surface texture and how this effects surface noise at the tyre/road interface.

1.2 Brief descriptions of bituminous surfacing materials and surface treatments are given in HD 26 (DMRB 7.2.3. and HD 31 (DMRB 7.4.1). Surface treatments for the maintenance of concrete roads are given in HD 32 (DMRB 7.4.2).

1.3 Detailed information on bituminous material types, and surfacing processes, together with advice on use, is presented in HD 37 (DMRB 7.5.2). Details of concrete surfacing and materials are given in HD 38 (DMRB 7.5.3). Reference should be made to the Specification (MCHW1) Series 700, 900 and 1000, together with the Notes for Guidance (MCHW2). For some materials there are British Standards and other published documentation and these are referenced in the appropriate chapters.

Implementation

1.3 This Part shall be used forthwith on all schemes for the construction, improvement and maintenance of trunk roads including motorways, currently being prepared provided that, in the opinion of the Overseeing Organisation this would not result in significant additional expense or delay. Design organisations should confirm its application to particular schemes with the Overseeing Organisation.

Mutual Recognition

1.4 The construction and maintenance of highway pavements will normally be carried out under contracts incorporating the Overseeing Organisation's Specification for Highway Works (MCHW1). In such cases products conforming to equivalent standards and specifications of other States of the European Economic Area and tests undertaken in the other States will be acceptable in accordance with the terms of the 104 and 105 Series of Clauses of that Specification. Any contract not containing these Clauses must contain suitable clauses of mutual recognition having the same effect regarding which advice should be sought.

2. Surfacing Options

2.1 The choice of surfacing materials/systems plays a vital role in providing roads that meet the needs of the user, that are safe and which give value for money. For many years hot rolled asphalt with chippings rolled into the surface has been the most widely used surfacing on trunk roads, including motorways, for both new construction and major maintenance. Recent years have however, seen the development of new materials and techniques, many of which are proprietary, that offer significant advantages, not just to the road user but also to the environment. For example noise generation may be reduced, delays at road works curtailed, ride quality improved and deformation resistance enhanced, all while maintaining existing safety levels. Furthermore new products such as energy efficient 'cold-lay' materials are in their development phase. This Chapter gives guidance on the range of surfacing options which are now available for both new construction and maintenance.

Performance Specifications

2.2 To remove barriers to trade and to encourage innovation, the Construction Products Directive (CPD) of the European Union requires the introduction of performance related specifications wherever possible. Specification clauses of this type have been included in the Specification for Highway Works (MCHW1&2) covering surfacings such as surface dressings (Clause 922), slurry and micro-surfacings (Clauses 918 & 927), high friction surfacing (Clause 924), porous asphalt (Clause 938), thin wearing course systems (Clause 942) and hot rolled asphalt (Clause 943). Performance is assessed either by testing samples from the laid material, testing the laid material in-situ or for proprietary systems, by assessment and approval in advance under the British Board of Agrément Highway Authorities Product Approval Scheme (BBA HAPAS). As BBA HAPAS becomes established it should be possible to simplify specification requirements where covered by the certification.

> 2.3 Where BBA HAPAS certification is specified but certificates are not yet in place, or in England HA Type Approval has not been given, the approval of the Overseeing Organisation shall be sought and a Departure agreed.

Choice of Surfacings

2.4 Apart from the suitability of surfacing materials in terms of safety and robustness, the permitted pavement surfacing options have been determined by the Overseeing Organisations, as indicated in Tables 2.2(E), (S), (NI) and (W), taking account of the variations across the UK of a number of factors:

- the nature of the existing network
- population density
- traffic intensity
- climatic conditions
- availability of materials

2.5 In locations where speeds are limited and tyre/road generated noise is low, or where traffic intensity and therefore the overall noise level is not very great, then the full range of surfacings options should be considered. For example, surface dressing systems should always be the first option to be examined for simple restoration of skid resistance, see HD 37 (DMRB 7.5.2) and for major maintenance, the brushed concrete surfacing option should be included. The decision on which options are to be included should be made on a site specific basis but none should be ruled out without justification.

2.6 Where noise levels are high due to the intensity of high speed traffic, a range of surfacing options is available that can reduce tyre/road generated noise emission. These are:

- hot paver-laid thin wearing course systems, Specification Clause 942 (MCHW 1),
- exposed aggregate concrete surfacing, commonly known as 'whisper concrete', Specification Clause 1044 (MCHW 1),
- porous asphalt, Specification Clause 938 (MCHW 1).

2.7 Advice on the different types of surfacings is given in HD 37 and 38 (DMRB 7.5.2 & 3), and a brief summary description provided in Table 2.1.

2.8 The surfacing options permitted shall be those shown in Tables 2.2E, 2.2S, 2.2NI and 2.2W, for England, Scotland, Northern Ireland and Wales respectively. Where an option is permitted "for use with restriction", any restriction listed in the relevant HD shall apply and reference should be made to the Overseeing Organisation.

2.9 In Table 2.2, high speed roads are defined as those with an 85th percentile traffic speed exceeding 90km/hr. The various construction types, eg. Flexible, Flexible Composite, are defined in HD 23 (DMRB 7.1.1).

Material	Summary Description
Brushed Concrete	The traditional transverse brushed concrete surface.
Burlap Drag & Tine Concrete Surface	The surface is finished using wet burlap (hessian) dragged behind the paving machine followed by transverse tining.
Exposed Aggregate Concrete Surface (EACS)	A quieter concrete surface with an exposed aggregate finish, commonly known as 'whisper' concrete.
Hot Rolled Asphalt Wearing Course (HRA)	A traditional surfacing material in the UK, formed by rolling pre-coated chippings into a stiff sand asphalt mat, to provide texture and skidding resistance.
Porous Asphalt (PA)	A mix in which the aggregates form a skeletal structure with interconnecting voids in excess of 20% allowing water to drain away within its thickness. Usually used for its noise suppression properties in the UK, it also reduces spray in wet weather.
Thin Surfacings	A range of materials, usually proprietary, that can restore skidding resistance and ride quality. Spray may also be reduced. Many have surfaces quieter than HRA. The range includes thin proprietary SMAs
Stone Mastic Asphalt (SMA)	A mix in which the aggregates form a skeletal structure, with a high binder content. Unless very carefully designed and controlled, mixes can be prone to loss of surface texture.
Bitumen Macadam	A mix with a continuous aggregate grading, with moderate resistance to deformation and providing low surface texture.
Surface Dressing	A system of one or more layers of sprayed binder and typically, single-sized chippings.
Slurry Surfacing and Micro-surfacing	Bitumen emulsion binder and aggregate mixed just prior to laying. No systems have as yet demonstrated the ability to retain satisfactory surface texture under heavy traffic.
High Friction Surfacing	Proprietary treatments using small sized high PSV aggregates for use in high-risk areas.

Table 2.1 Summary Description of Material Types

Road Category		High Speed Roads		Low Speed Roads	
	HD No	New Construction	Maintenance Construction	New Construction	Maintenance Construction
FLEXIBLE					
HRA	HD37ch4	x	R	x	R
Coated Macadam		x	x	x	x
Porous Asphalt	HD37ch5	R	R	R	R
Thin Surfacings	HD37ch6	✓	✓	✓	✓
SMA	HD37ch7	x	x	x	x
Surface Dressing	HD37ch8	x	R	x	R
Slurry / Micro Surfacing	HD37ch10	x	x	x	R
FLEXIBLE COMPOSITE					
HRA	HD37ch4	x	R	x	R
Coated Macadam		x	x	x	x
Porous Asphalt	HD37ch5	x	x	x	x
Thin Surfacings	HD37ch6	✓	✓	✓	✓
SMA	HD37ch7	x	x	x	x
Surface Dressing	HD37ch8	x	R	x	R
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R
RIGID					
Whisper Concrete	HD38 Ch 3	✓	✓	✓	✓
Brushed / Burlap Drag / Tined	HD38 Ch 2	x	R	x	R
HRA	HD37ch4	x	R	x	R
Porous Asphalt (CRCP only)	HD37ch5	x	R	x	R
Thin Surfacings	HD37ch6	R	✓	R	✓
SMA	HD37ch7	x	x	x	x
Surface Dressing	HD37ch8	x	R	x	R
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R
RIGID COMPOSITE					
HRA	HD37ch4	x	R	x	R
Porous Asphalt	HD37ch5	R	R	R	R
Thin Surfacings	HD37ch6	✓	✓	✓	✓
SMA	HD37ch7	x	x	x	x
Surface Dressing	HD37ch8	x	R	x	R
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R

✓ For use without restriction   R For use with restriction   x Not permitted

TABLE 2.2E (England): Permitted Pavement Surfacing Materials for New and Maintenance Construction

Road Category		High Speed Roads		Low Speed Roads	
	HD No	New Construction	Maintenance Construction	New Construction	Maintenance Construction
FLEXIBLE					
HRA (See Note 1)	HD37ch4	✓	✓	✓	✓
Coated Macadam		x	x	x	x
Porous Asphalt	HD37ch5	R	R	R	R
Thin Surfacings (See Note 2)	HD37ch6	R	R	R	R
SMA	HD37ch7	R	R	R	R
Surface Dressing (See Note 1)	HD37ch8	x	R	x	R
Slurry / Micro Surfacing	HD37ch10	x	x	x	R
FLEXIBLE COMPOSITE					
HRA (See Note 1)	HD37ch4	✓	✓	✓	✓
Coated Macadam		x	x	x	x
Porous Asphalt	HD37ch5	x	x	x	x
Thin Surfacings (See Note 2)	HD37ch6	R	R	R	R
SMA	HD37ch7	R	R	R	R
Surface Dressing (See Note 1)	HD37ch8	x	R	x	R
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R
RIGID					
Whisper Concrete	HD38 Ch 3	✓	✓	✓	✓
Brushed / Burlap Drag / Tined	HD38 Ch 2	✓	✓	✓	✓
HRA (See Note 1)	HD37ch4	x	✓	x	✓
Porous Asphalt (CRCP only)	HD37ch5	x	R	x	R
Thin Surfacings (See Note 2)	HD37ch6	R	R	R	R
SMA	HD37ch7	x	R	x	R
Surface Dressing (See Note 1)	HD37ch8	x	R	x	R
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R
RIGID COMPOSITE					
HRA (See Note 1)	HD37ch4	✓	✓	✓	✓
Porous Asphalt	HD37ch5	R	R	R	R
Thin Surfacings (See Note 2)	HD37ch6	R	R	R	R
SMA	HD37ch7	R	R	R	R
Surface Dressing (See Note 1)	HD37ch8	x	R	x	R
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R

✓ For use without restriction **R For use with restriction** **x Not permitted**

Note 1: See Paragraphs 2.5 & 2.6 in relation to noise Note 2: See Paragraph 2.3 in relation to HAPAS

TABLE 2.2S (Scotland): Permitted Pavement Surfacing Materials for New and Maintenance Construction

This table is for use in Scotland only

Road Category		High Speed Roads		Low Speed Roads	
	HD No	New Construction	Maintenance Construction	New Construction	Maintenance Construction
FLEXIBLE					
HRA (See Note 1)	HD37ch4	✓	✓	✓	✓
Coated Macadam		x	x	✓	✓
Porous Asphalt	HD37ch5	R	R	R	R
Thin Surfacings (See Note 2)	HD37ch6	✓	✓	✓	✓
Generic SMA	HD37ch7	x	x	R	R
Surface Dressing (See Note 1)	HD37ch8	x	✓	x	✓
Slurry / Micro Surfacing	HD37ch10	x	x	x	R
FLEXIBLE COMPOSITE					
HRA (See Note 1)	HD37ch4	✓	✓	✓	✓
Porous Asphalt	HD37ch5	x	x	x	x
Thin Surfacings (See Note 2)	HD37ch6	✓	✓	✓	✓
Generic SMA	HD37ch7	x	x	R	R
Surface Dressing (See Note 1)	HD37ch8	x	✓	x	✓
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R
RIGID					
Whisper Concrete	HD38 Ch 3	✓	✓	✓	✓
Brushed / Burlap Drag / Tined	HD38 Ch 2	R	R	✓	✓
HRA (See Note 1)	HD37ch4	x	✓	x	✓
Porous Asphalt (CRCP only)	HD37ch5	x	R	x	R
Thin Surfacings (See Note 2)	HD37ch6	x	R	x	R
Generic SMA	HD37ch7	x	x	x	R
Surface Dressing (See Note 1)	HD37ch8	x	✓	x	✓
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R
RIGID COMPOSITE					
HRA (See Note 1)	HD37ch4	✓	✓	✓	✓
Porous Asphalt	HD37ch5	R	R	R	R
Thin Surfacings (See Note 2)	HD37ch6	✓	✓	✓	✓
Generic SMA	HD37ch7	x	x	R	R
Surface Dressing (See Note 1)	HD37ch8	x	✓	x	✓
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R

✓ For use without restriction **R For use with restriction** **x Not permitted**

Note 1: See Paragraphs 2.5 & 2.6 in relation to noise Note 2: See Paragraph 2.3 in relation to HAPAS

TABLE 2.2NI (Northern Ireland): Permitted Pavement Surfacing Materials for New and Maintenance Construction

Road Category		High Speed Roads		Low Speed Roads	
	HD No	New Construction	Maintenance Construction	New Construction	Maintenance Construction
FLEXIBLE					
HRA	HD37ch4	R	R	R	R
Coated Macadam		x	x	x	x
Porous Asphalt	HD37ch5	R	R	R	R
Thin Surfacings	HD37ch6	✓	✓	✓	✓
SMA	HD37ch7	x	x	x	x
Surface Dressing	HD37ch8	x	R	x	R
Slurry / Micro Surfacing	HD37ch10	x	x	x	R
FLEXIBLE COMPOSITE					
HRA	HD37ch4	R	R	R	R
Coated Macadam		x	x	x	x
Porous Asphalt	HD37ch5	x	x	x	x
Thin Surfacings	HD37ch6	✓	✓	✓	✓
SMA	HD37ch7	x	x	x	x
Surface Dressing	HD37ch8	x	R	x	R
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R
RIGID					
Whisper Concrete	HD38 Ch 3	✓	✓	✓	✓
Brushed / Burlap Drag / Tined	HD38 Ch 2	R	R	R	R
HRA	HD37ch4	x	R	x	R
Porous Asphalt (CRCP only)	HD37ch5	x	R	x	R
Thin Surfacings	HD37ch6	R	✓	R	✓
SMA	HD37ch7	x	x	x	x
Surface Dressing	HD37ch8	x	R	x	R
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R
RIGID COMPOSITE					
HRA	HD37ch4	R	R	R	R
Porous Asphalt	HD37ch5	R	R	R	R
Thin Surfacings	HD37ch6	✓	✓	✓	✓
SMA	HD37ch7	x	x	x	x
Surface Dressing	HD37ch8	x	R	x	R
Slurry Seal / Micro Surfacing	HD37ch10	x	x	x	R

✓ For use without restriction   R For use with restriction   x Not permitted

TABLE 2.2W (Wales): Permitted Pavement Surfacing Materials for New and Maintenance Construction

3. TEXTURE AND AGGRREGATE PROPERTIES

3.1 Friction between the tyre and road surface consists of two main components, both of which are related to speed.

a) Sliding resistance between tyre and road surface with its magnitude determined by the nature of the materials in contact.

b) Loss of energy caused by deformation (hysteresis) of the tyre.

Therefore during a single braking operation the friction available to the vehicle is not constant.

3.2 In dry conditions all clean, surfaced roads have a high skidding resistance. The fine scale **microtexture** (see Figure 3.1) of the surface aggregate is the main contributor to sliding resistance and is the dominant factor in determining wet skidding resistance at lower speeds. Coarse **macrotexture** which provides rapid drainage routes between tyre and road surface, and tyre resilience as well as the fine scale micro- texture are important factors in determining wet skidding resistance at high speeds. **Megatexture** relates to the roughness of the road and has no effect on skidding resistance but effects noise, (see Chapter 5 of this Part for details).

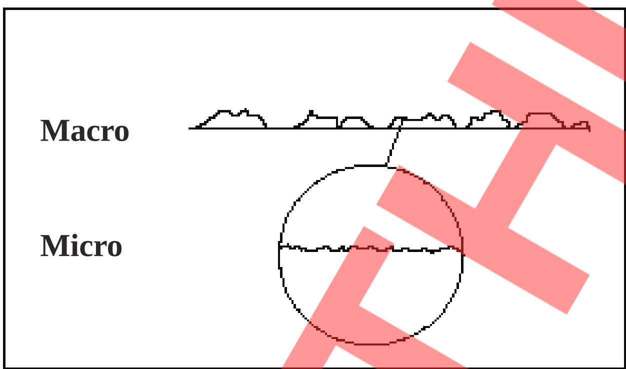

FIGURE 3.1 Surface Texture

3.3 The skidding resistance of wet roads is reduced by the lubricating action of the film of water on the wet road surface. Drainage channels provided by the large scale texture (macrotexture) and/or the pattern on the tyre, assist in getting rid of the bulk of the water and are of increasing importance the higher the speed. Penetration of the remaining water film can be achieved only if there are sufficient fine scale sharp edges (microtexture) on the road surface on which the tyre can build up high contact pressures to establish areas of 'dry' contact between the road and the tyre.

3.4 Aquaplaning is the condition where the vehicle tyres are completely supported by a layer of water and there is no contact with the road surface. High speed and a thick film of water on the road surface encourage a vehicle to aquaplane, but a relatively thin layer of water could cause a problem if combined with low texture depth and 'smooth' tyres. Although aquaplaning itself is not regularly identified, conditions may often exist where a high proportion of tyre/road contact is lost.

3.5 Because of the effects of weight transfer when braking and/or cornering some wheels are likely to skid earlier than the skidding resistance of the road surface alone indicates. In addition, if brakes are out of adjustment and hence the distribution of braking effort on the wheels is uneven, the minimum skidding resistance required to avoid skidding will be increased still further, as more of the retarding force will have to be taken by the wheels of the functioning brakes.

MICRO-TEXTURE

3.6 The micro-texture characteristics of a particular stone depend on its polishing susceptibility under the action of tyre forces.

Measurement

3.7 The accelerated polishing machine (Figure 3.2) is used on aggregates to simulate the polishing action of traffic. The Polished Stone Value (PSV) test, which is specified in BS812, requires 6 hours of polishing designed to produce a state similar to that which the aggregate would be subjected to under actual traffic when equilibrium conditions are reached.

FIGURE 3.2 Accelerated Polishing Machine

3.8 The portable skid-resistance tester (Figure 3.3) is used to determine the skid resistance value of the aggregate after polishing. This is termed the Polished Stone Value (PSV).

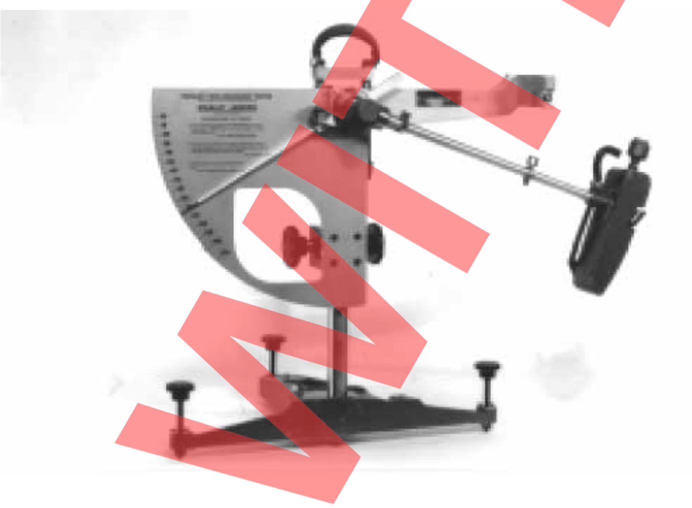

FIGURE 3.3 Portable Skid Resistance Tester

3.9 Aggregate durability is measured by the Aggregate Abrasion Value (AAV) test as defined in BS812. The AAV is a measure of the durability or resistance to abrasion of an aggregate under the action of traffic.

Aggregate Selection

3.10 To determine the correct PSV and AAV for a particular site the designer should have regard to the extent and scale of the work. When specifying a PSV it is undesirable to have too frequent changes of aggregate and the aim should be to specify and provide the most economical aggregate available over the longest possible lengths. The highest PSV aggregates should be restricted to those locations where they are required such as on bends and gradients, and at intersections and junctions.

3.11 The minimum PSVs to be applied to different categories of site and related to traffic flow are given in Table 3.1. The appropriate AAVs are given in Table 3.2. Tables 3.1 and 3.2 refer to both new works and maintenance and values of PSV and AAV shall be inserted into the appropriate part of Appendix 7/1 of the Specification (MCHW1). The minimum values of PSV given in Table 3.1 are the values to be used if no other information is available. On an existing site, if the life that has been achieved by the aggregates, the skid resistance and the skidding accident rate have all been satisfactory, then the continued use of the same aggregate source, albeit with a lower PSV than that given in Table 3.1 may be considered. If however, the measured skid resistance of the site when related to the life achieved and the skidding accident rate are below expectations for an aggregate from a particular source, then a higher PSV than that given in Table 3.1 may be specified.

3.12 Although some lengths of motorway are carrying traffic volumes in excess of 6000 commercial vehicles per lane per day, PSVs in excess of those shown in Table 3.1 should not be specified. Where blank spaces have been left in Table 3.1 it is considered that such traffic flows in these locations will not be achieved.

IL Band	Default IL	Site Categories		Traffic (cv/lane/day) at design life									
			Site Definitions	**0-250**	**251-500**	**501-750**	**751-1000**	**1001-2000**	**2001-3000**	**3001-4000**	**4001-5000**	**5001-6000**	**Over 6000**
I	0.35	A,B	Motorway (mainline), Dual carriageways (non-event)	50	50	50	50	50	55	60	60	65	65
Ia	0.35	A1	Motorway mainline, 300 m approaches to off-slip roads	50	50	50	55	55	60	60	65	65	65
II	0.40	C,D	Single carriageways (non-event), dual carriageways approaches to minor junctions	50	50	50	55	60	65	65	65	65	68+
III	0.45	E, F, G1, H1	Single carriageways minor junctions, approaches to and across major junctions, gradients 5-10%>50m (dual, downhill only), bends <250m radius >40mph	55	60	60	65	65	68+	68+	68+	68+	70+
IV	0.50	G2	Gradients >50m long >10%	60	68+	68+	70+	70+	70+	70+	70+	70+	70+
V	0.55	J,K	Approaches to roundabouts, traffic signals, pedestrian crossings, railway level crossings and similar	68+	68+	68+	70+	70+	70+	70+	70+	70+	70+
VI	0.55 (20 km/h)	L	Roundabouts	50-70+	55-70+	60-70+	60-70+	60-70+	65-70+	65-70+			
VII	0.60 (20 km/h)	H2	Bends < 100m	55-70+	60-70+	60-70+	65-70+	65-70+	65-70+	65-70+			

Notes:
1. 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. See Paragraph 3.21.
2. Throughout this Table ’70+’ means that specialised high-skidding resistance surfacings complying with MCHW1 Clause 924 will be required.
3. For site categories L and H2, a range is given and the PSV should be chosen on the basis of local experience of material performance. In the absence of other information, the highest values should be used.
4. Investigatory Level (IL) is defined in Chapter 3 of HD 28 (DMRB 7.3.1).

Table 3.1 Minimum PSV of Chippings, or Coarse Aggregate in unchipped surfaces, for new wearing courses

Traffic (cv/lane/day) at design life (see 3.15)	<250	251-1000	1001-1750*	1751-2500	2501-3250	>3250
Max AAV for chippings for hot rolled asphalt and surface dressing, and for aggregate in slurry and microsurfacing systems	14	12	12	10	10	10
Max AAV for aggregate in thin wearing course systems, exposed aggregate concrete surfacing and coated macadam wearing course	16	16	14	14	12	12

Note 1: For roads carrying less than 1750 cv/lane/day, aggregate of higher AAV may be used where experience has shown that satisfactory performance is achieved by an aggregate from a particular source.

Note 2: The maximum AAV requirement for porous asphalt is specified in Clause 938 of the Specification (MCHW 1).

TABLE 3.2 Maximum AAV of chippings, or coarse aggregates in unchipped surfaces, for new wearing courses

3.13 The PSVs in Table 3.1 are related to the investigatory levels (IL) for different traffic flows set out in Chapter 3 of HD 28 (DMRB 7.3.1). A margin of safety has been added for each of the following reasons:-

a) To allow for variability of aggregates, the precision of the PSV test and variations in estimating traffic flows;

b) To allow for turning movements and traction/braking forces at major junctions and on gradients;

c) Where possible, to ensure that the skidding resistance achieved on trunk roads does not fall below the requirements within the lifetime of the surfacing. This avoids frequent maintenance on high speed and other trunk roads with consequent traffic delays.

NOTE: Investigatory levels for bends (H2) and roundabouts (L) are higher than for the corresponding sections of the same road system because MSSC readings at 20kph are higher than those measured at the standard 50kph for the same type of surface.

3.14 Using the appropriate PSV for a particular site and traffic loading should result in a surfacing giving satisfactory performance before reaching the investigatory level of Mean Summer SCRIM Coefficient. See Chapter 3 of HD 28 (DMRB 7.3.1).
.

3.15 The traffic flow used to determine the appropriate PSV and AAV for a particular surfacing shall be the maximum volume of traffic measured as commercial vehicles per lane per day (cv/lane/day) based on the Average Annual Daily Flow (AADF) calculated to be using the lane at the end of the anticipated life of the surfacing - see HD 24 (DMRB 7.2.1). Estimates of traffic growth rates and life of the surfacing may be based on local experience.

3.16 The same levels of PSV and AAV shall be used on different traffic lanes across the carriageway and in the hardshoulder except that, where aggregates are used for demarcation, a maximum difference of 5 PSV points may be allowed.

3.17 The PSVs given in Table 3.1 apply to roads constructed within current design standards, and will provide satisfactory skidding resistance on sites of average difficulty within the general site category for the life of the surfacing. There may be instances where, because of special difficulties or departures from standard layout designs, it will be necessary to increase the 'risk rating' of a site in accordance with the method given in paragraphs 3.42 to 3.53 of HD 28 (DMRB 7.3.3) and hence utilise an aggregate of higher PSV.

3.18 For site categories L and H2 ranges of PSV are set out in Table 3.1. The PSV to be specified should be selected on the basis of local experience of material performance. For maintenance resurfacing, the current skid resistance in relation to the life achieved and the skidding accident rate should be considered. If satisfactory, the PSV and AAV of the new surfacing aggregate should be the same as the aggregates used previously. If considered unsatisfactory, the PSV should be increased within the range given for the appropriate traffic level. For new construction, existing sites with similar traffic flows, site geometry and visibility should be used to assist in determining the initial values of PSV and AAV to be specified. In the absence of any such suitable information, the highest value in the range should be specified.

3.19 The actual PSVs, AAVs and texture depths built into schemes of new construction and the assumptions on which the minimum values were selected shall be recorded and maintained in a readily available form, (eg. the scheme maintenance manual). Standards to be adopted in subsequent renewal work may then be determined in the light of the skidding resistance performance set against those initial recorded values.

3.20 The requirements of Tables 3.1 and 3.2 cover:-

a) Chippings for surface dressing.

b) The coarse aggregate in thin wearing course systems, porous asphalt, bitumen macadam wearing courses and wearing courses of rolled asphalt and dense tar surfacing without coated chippings applied to the surface;

c) Coated chippings applied to the surface of rolled asphalt, to mastic asphalt and to fine graded macadam;

d) Coarse aggregate in slurry surfacing and microsurfacing systems;

e) The coarse aggregate in non-surface dressed basecourses of bitumen macadam or stone mastic asphalt and roadbases of bitumen macadam or rolled asphalt used as temporary surfaces by general traffic for prolonged periods and not subject to speed restrictions or without warning signs;

3.21 Samples of the chippings representative of those to be incorporated into the works should be tested in accordance with BS812 for compliance with the specified PSV and AAV properties. Alternatively, except where a PSV of 68+ is specified, the aggregate shall be deemed to comply if the mean of the 3 most recent results from consecutive tests, relating to the material to be supplied, is greater than or equal to the specified PSV and less than the specified AAV. Where a PSV of 68+ is specified, none of the three most recent results from consecutive tests shall be less than 68. Tests must have been carried out in the previous 6 months by a laboratory accredited by NAMAS for these tests or by a laboratory in a member state of the European Community (other than the UK) which can demonstrate suitable and satisfactory evidence of technical and professional competence and independence for such tests. The latter requirement shall be satisfied if the laboratory is accredited in a member state of the European Communities in accordance with the relevant parts of EN45000 series of standards for the tests carried out.

3.22 It is essential that the chippings supplied to site shall be the same in all respects to the sample submitted for acceptance. If it is considered that there is a change in the material delivered to site, fresh tests shall be ordered.

3.23 There are few quarries which can supply chippings whose PSV is consistently over 68 together with a maximum AAV of 10. In order to achieve values in excess of this, it is necessary to specify a resin-based high friction surface treatment as described in Clause 924 of the Specification (MCHW1). Although highly skid resistant, material complying with Clause 924 is unable to meet the requirement of a texture depth of 1.5mm (measured by the sand patch test), therefore on high speed roads this type of material should only be used where strictly necessary eg. for braking sections and tight curves. When such materials are to be used on high speed roads, attention should be given to the need to drain water off the surface by profiling or by other means.

3.24 The PSV of 70+ is considered to be the highest practical level that can be consistently achieved using artificial aggregate such as calcined bauxite. For heavily stressed sites the use of a small size, hard aggregate with a PSV of 70+ effectively increases the initial skidding resistance provided and thereby extends its ‘life’, ie. the period before the investigatory level is reached. This effective increase in skidding resistance also increases the stress on the chippings, hence the necessity to use a binder modified with an epoxy or a similar resin. Advice is given in Chapter 9 of HD 37 (DMRB 7.5.2) and also in Series 900 of the Notes for Guidance to the Specification (MCHW2).

3.25 To decide whether a high PSV stone should be used for renewing a surface, consideration should be given to the PSV and AAV of the existing aggregate in relation to the life achieved, the current skid resistance of the surface and the skidding accident rate of the site. If all are satisfactory, the use of stone from the same source and of the same PSV may be appropriate. Where records of PSV and AAV are not available, identification of the source of an aggregate may enable values that are sufficiently accurate for assessment purposes to be estimated.

MACRO-TEXTURE

3.26 Adequate macro-texture is required for the rapid drainage of surface water from the tyre and road pavement interface thereby reducing the chance of aquaplaning. The texture depth is a measure of the macro-texture and is an important factor influencing skidding in wet conditions on high speed (>90km/h) roads.

3.27 Surface texture takes two forms:-

a) ‘positive’ texture: a cluster of angular peaks or series of ridges above a datum level, typical of surface dressings, rolled asphalt, slurry and microsurfacings and brushed concrete;

b) ‘negative’ texture: a network of depressions or series of grooves below the general level, typical of thin wearing course systems, macadam surfacings, porous asphalt and exposed aggregate concrete surfacing.

3.28 Ideally, choice of an appropriate texture depth would be made on the basis of values related to accident occurrence which could then become part of a maintenance policy. However, until research results are available, the approach is to specify minimum levels of texture depth for new high-speed roads to apply at construction or major maintenance. This is given in Series 900 and 1000 of the Specification (MCHW1).

3.29 For speeds in excess of 90km/h the texture depth of the surface should be that required by the Specification (MCHW1). This will ensure that the skid resistance is maintained and facilitate the rapid drainage of water from the road surface. At lower speeds, texture depth is less important and compliance with the more general specification requirements or with specified rates of spread of chippings should be sufficient. With lower speed roads, micro texture is the major factor in maintaining skid resistance, although texture is still important. In bituminous and exposed aggregate concrete roads, micro texture is provided by the use of a surface aggregate with a specified resistance to polishing given by the Polished Stone Value (PSV).

Measurement

3.30 For many years texture depth has been measured by the 'sand patch' method in which a known volume of sand is spread into a circular patch. The diameter of the patch is measured and the average depth under the peaks in the surface calculated. This is the specified reference method and advice on the measurement of surface texture is contained in the Notes for Guidance to the Specification (MCHW2).

3.31 More recently laser-based techniques have become available which determine the texture depth albeit by a different methodology.

Mini-Texture Meter (MTM)

3.32 The MTM (Figure 3.4) consists of a laser sensor mounted in a special two-wheeled hand propelled trolley, with a micro-computer and printer mounted in the handle. The machine is operated at walking pace by one person, can be operated on hot, newly laid surfacings and is an ideal tool for obtaining results within hours of completion. A special sensitivity mat is required to calibrate the unit before use on new surfacings. The machine should also be calibrated against the reference 'sand patch' method for any particular surface in question. The equipment is not suitable for long distance high speed surveys and was developed to monitor compliance with texture depth requirements for newly laid surfacing. Further details are contained in the Notes for Guidance (MCHW2).

The measurement of texture at high speed

3.33 It is possible to measure texture indirectly using lasers at speeds up to 100km/h. This method has been incorporated in a number of devices; the High Speed Texture Meter (Figure 3.5), the High Speed Road Monitor (HRM) and the SCRIMTEX. The HRM is described more fully in HD29 (DMRB 7.3.2) In England, the Highways Agency research tool HARRIS (Highways Agency Road Research Information System) and the planned replacement for the HRM, Traffic Speed Condition Surveys (TRACS) use a similar system of reflected light to determine texture depth.

MATERIAL CHARACTERISTICS

Hot Rolled Asphalt

3.34 This material has historically been the most widely used surfacing on trunk roads. The texture is formed by rolling coated chippings into the asphalt mat. This technique requires good site control procedures to achieve the correct combination of rate of spread of chippings and compaction. If the spread rate is too high, good initial texture is obtained but rapid loss of chippings can occur when the road opens to traffic. Embedment of chippings may occur if the material is too hot when rolled or rolling is poorly controlled resulting in low texture depth.

Surface Dressing

3.35 This technique is widely used throughout the UK and is a cost effective maintenance treatment. It provides very high initial textures reducing gradually as the traffic causes embedment of the chippings into the surface. This reduction in texture should not significantly affect the skidding resistance values of a well designed system and textures in excess of 1.5mm (sand patch method) should normally be maintained.

FIGURE 3.4 Mini-Texture Meter (MTM)

FIGURE 3.5 High Speed Texture Meter (HSTM)

Thin Wearing Course Systems

3.36 Thin wearing course systems or thin surfacings as they are more commonly known, are proprietary surfacing systems and are coming into widespread use. They are fast to lay and quieter than either hot rolled asphalt, conventional surface dressing or brushed concrete surfaces. Hot, paver laid thin surfacings comprising specifically graded aggregates mixed with bitumen binder, customarily modified with polymer or fibre, to generally achieve, after compaction, significant negative texture. The aggregates form a skeletal structure providing good resistance to deformation, but their grading has to be carefully controlled to avoid the closing up of voids and consequent loss of texture. As thin surfacings are proprietary products requiring BBA HAPAS certification, a two year warranty including texture retention in the wheeltracks is required.

Macadams

3.37 Most coated macadam mixes are a combination of different size aggregate particles mixed with binder and formed into a mat to give a new running surface. The surface texture is provided by the small interstices between adjacent aggregate particles and tends to be low. Macadams are therefore rarely used for the surfaces of high speed roads.

Porous Asphalt

3.38 Porous Asphalt has been developed with the objective of reducing spray and has the added advantage of reducing running noise. It is designed to provide drainage through the body of the material thereby reducing the amount of surface water and hence spray. Porous Asphalt consists largely of a single-size aggregate held together by binder with interconnecting voids (giving high texture depth) through which water can pass. It acts like a sponge until it is almost saturated and then, providing the cross-falls have been designed appropriately, as a lateral drain. It is laid as the wearing course of the pavement structure with an impermeable basecourse layer below it in order to protect the lower layers of the pavement from ingress of water.

Brushed Concrete Surfacing

3.39 The skid resistance of a brushed concrete road depends upon the type and depth of the surface texture and the resistance of the aggregates, particularly the fine aggregate, in the surface of the slab to polishing and abrasion.

3.40 Natural sands having a high silica content produce concrete with a higher skid resistance than do other fine aggregates. In particular it has been found that the amount of acid-soluble material in the fine aggregate affects the skid resistance of the concrete road, high acid solubility associated with low resistance being attributed to the presence of limestone in the fine aggregate.

3.41 The reduction of skid resistance to undesirably low values results from the loss of surface texture and polishing caused by the action of traffic. The rate at which this occurs is largely proportional to the amount of traffic using the road. The skid resistance of worn surfaces can be improved by the application of a surface dressing or a suitable thin wearing course system. Small areas can be treated by grooving or mechanically roughening the deficient areas. When selecting a treatment, due consideration should be given to the cost, the effect on traffic while work is in progress and the long term effectiveness of the treatment. Grooved surface textures are long lasting and durable. In addition to providing good high speed skidding resistance, grooves sawn at right angles to the direction of travel assist in the effective drainage of surface water, prevent aquaplaning and considerably reduce spray. A suitable pattern of groove spacing is given in Series 1000 of the Specification (MCHW1). Care must be taken in order to limit the volume of noise from such a surface. It has been found that irregular spacing helps reduce tyre/surface noise.

3.42 Improved skidding resistance can also be achieved by roughening the worn surface by use of scabbling, milling or abrasive blasting equipment. Abrasive blasting is effective in restoring microtexture and equipment is available for treating large and small areas. The effectiveness of the surface texture produced by scabbling and milling will be influenced by the properties and characteristics of the coarse aggregate in the concrete which is exposed. Advice on the effectiveness of these treatments is given in Chapter 4 of HD 38/99 (DMRB 7.5.3).

Burlap Drag and Tined Concrete

3.43 An alternative to brushing a concrete surface to achieve transverse texture is a technique called burlap drag and tine. This has been widely used in America and can now be used in the UK. The burlap (wet hessian) is dragged over the surface after it has been regulated to give it microtexture. The tined texture is produced using a head carrying steel tines which is drawn transversely across the surface.

Exposed Aggregate Concrete surfacing

3.44 Concrete roads with exposed aggregate surfaces are coming into use for new construction or major maintenance as they are quieter than conventional brushed concrete or hot rolled asphalt surfacings. The texture is provided by retarding the hydration of the cement paste in the surface of the road immediately following compaction and final smoothing. The retarded surface layer of cement and fine aggregate is then removed by mechanically brushing after the underlying concrete has set, to partially expose the surface layer of carefully graded coarse aggregate, thus providing the requisite texture.

5. TYRE/ROAD SURFACE NOISE

GENERAL

5.1 Noise from road traffic has become, over the last few years, a very contentious environmental issue. Where traffic speeds are lower than 50 km/hr, traffic noise is mainly attributable to engine, transmission and exhaust noise, especially from lorries. Where speeds are higher, the major component of traffic noise comes from the tyre/road interface. This noise comes from, amongst other things, vibration of the tyre wall, compression of air within the contact area of the tyre, and the snapping out of the tread blocks as they leave the road surface. The quality of the road surface, tyre design and vehicle speeds all have an effect on tyre noise.

5.2 Details of the available low noise surfacings and where there may be used is given in Chapter 2 of this Part.

5.3 For many years it has been the UK practice to ensure that there are interconnecting drainage paths within the surface over which the tyre runs to help disperse water and improve skidding resistance, particularly at high speeds. It was also recognised that the coarseness of the surface contributes to traffic noise. This coarseness has traditionally been measured by the sand patch test which gives the average depth of texture over an area similar to the contact patch of a tyre.

Definitions of Texture Depths

5.4 It is now recognised that there are a number of factors within the road surface texture that play significantly different roles in improving skidding resistance and generating noise. It is helpful to distinguish different scales of texture by defining the roles of the texture ranges as follows:-

i) The fine scale microtexture of the surface aggregate is the main contributor to skidding resistance and is the dominant factor in determining skidding resistance at lower speeds.

ii) Macrotexture provides rapid drainage routes between the tyre and the road surface and contributes to the wet skidding resistance at higher speeds. It also allows air trapped beneath the tyre to escape.

iii) Megatexture at a scale comparable with the tyre contact patch is mainly associated with tyre noise. Surfaces with high mega-texture include HRA with gaps between groups of chippings and the old-style cobbled surfacings.

iv) Unevenness in the longer ranges cause large tyre and suspension movements that affect the handling of vehicles.

5.4 Fig 5.1 shows the difference between micro-, macro-, and mega-texture lengths and depths.

5.5 The texture depth is the average deviation of a road surface from a true planar surface within any category of texture. It is represented at the road surface as:-

i) Microtexture

The roughness of the surface aggregate, which is associated with the crystalline structure of the coarse aggregate and the sand particles in the surface laitance of a brushed concrete surface.

ii) Macrotexture

Represents the height above a road surface of the aggregate chipping (eg for HRA, surface dressing & brushed concrete), or the depth of texture below the road surface (eg for porous asphalt, thin surfacings, tined and exposed aggregate concrete surfaces, (EACS)).

ii) Megatexture

Represents the degree of smoothness of the surface.

iv) Unevenness

Describes amplitudes of longer wavelengths which affect vehicle suspensions.

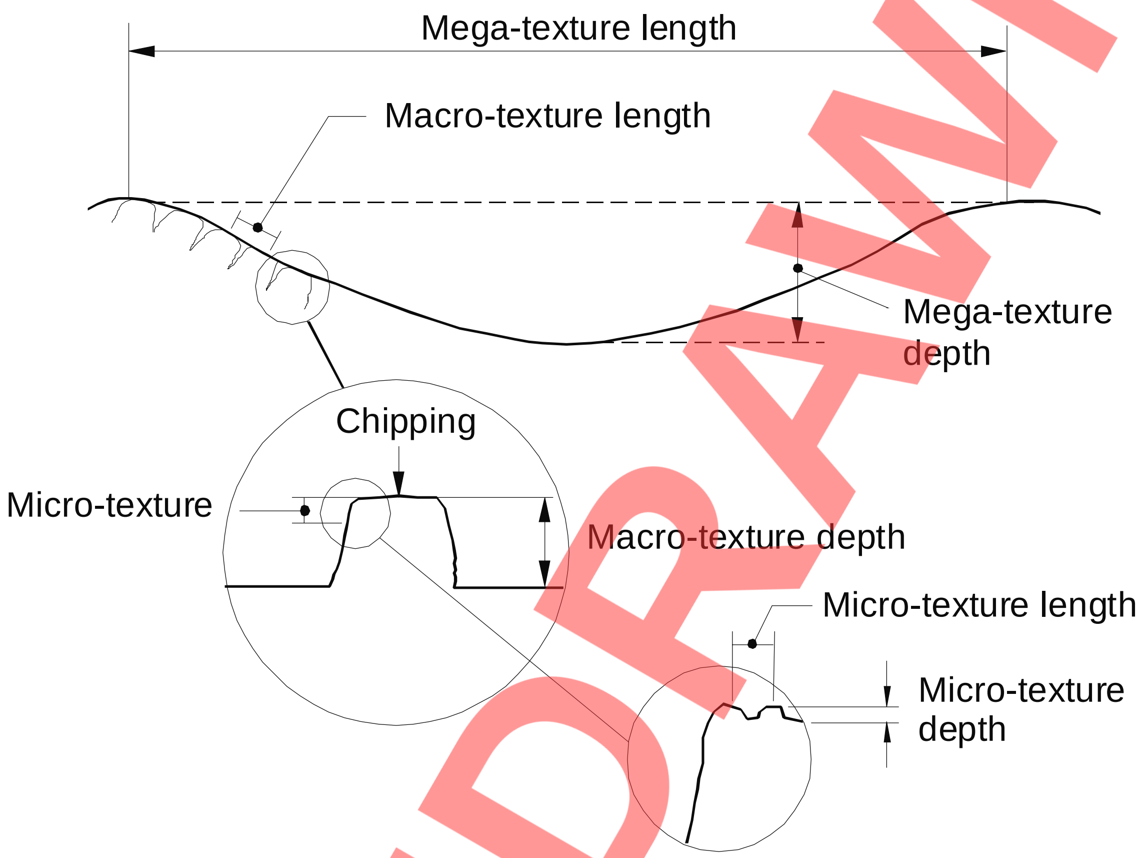

Figure 5.1 Details of texture length and depths

5.6 The effect of texture on noise and skidding is given in Table 5.1.

5.7 With recently developed laser based equipment the depth of the texture can be measured separately within each texture range. The objective of modern surfacing techniques is to reduce the depth of texture in the megatexture range as much as possible, while retaining an adequate depth of macrotexture to provide high speed skidding performance. Low speed skidding performance is mainly controlled by the microtexture. The inter-relationship of the effects of different types of texture on skidding resistance and noise generation are shown in Fig 5.2.

Positive and Negative Texture Depths

5.8 An important difference between surfaces, which has a strong effect on noise generation, is the degree to which the surface aggregate particles protrude above the plane of the tyre contact patch. Surfaces which are formed by rolling aggregate chippings into the soft surface of an underlying matrix during construction are described as positive texture. Those in which the aggregate chippings are embedded at the surface within the matrix,

Range	Texture length (mm)	Texture depth/ noise properties	Skidding resistance
Microtexture	< 0.5	Little noise contribution	Low speed
Macrotexture	0.5-10	Deep texture = low noise	High speed
	10-50	Low texture = low noise	High speed
Megatexture	50-500	Low texture = low noise	High speed
Uneveness	> 500	Suspension noise	Ride quality/ handling

Table 5.1 Contribution of Texture Depth to Noise and Skidding

leaving voids which are generally below the plane of the contact patch, are described as having a negative texture. For the same texture depth the latter generate much less tyre noise. Brushing concrete road surfaces also produces a positive texture but this process may, unless care is taken, build up unwanted megatexture depths (see paragraph 5.20 for further details).

5.9 Positive and negative texture types are shown in Fig 5.3. Hot rolled asphalt, surface dressing and brushed concrete surfaces are generally considered to be positively textured whereas porous asphalt, thin surfacing and exposed aggregate concrete surfaces are generally considered to be negatively textured.

Aggregate Shape

5.10 The shape of the aggregate particles that are provided at the surface to provide for skidding resistance also can have an effect on noise. Particles of a more cubical nature with a lower flakiness index pack better into the surface to provide a flatter area on which the tyre can run. At a detailed level it can be seen that the tyre contact is spread more evenly over the contact area, which in itself reduces the apparent contact patch. Conversely a rougher surface increases the contact patch, which exacerbates tyre/road noise as the noise is relative to the length of the escape path for the trapped air.

5.11 Road surfaces with negative textures, provided there is sufficient interconnection between the voids below the running surface, reduce the amount of noise generated by reducing the air pressures within the contact area. At high speed the compression and release of air trapped under the tyre is a significant component of tyre noise.

5.12 These observations can be translated into practical advice for the design and construction of roads with lower noise surfaces. Advice for controlling texture ranges is given in paragraphs 5.13 to 5.21.

Microtexture

5.13 The amplitudes of microtexture for bituminous surfaces and EACS come from the roughness of the surface of the coarse surfaces the microtexture comes from the fine aggregate (sand). High amplitudes of microtexture have a minimal, if any, effect on the tyre/road noise, but provide low speed skidding resistance.

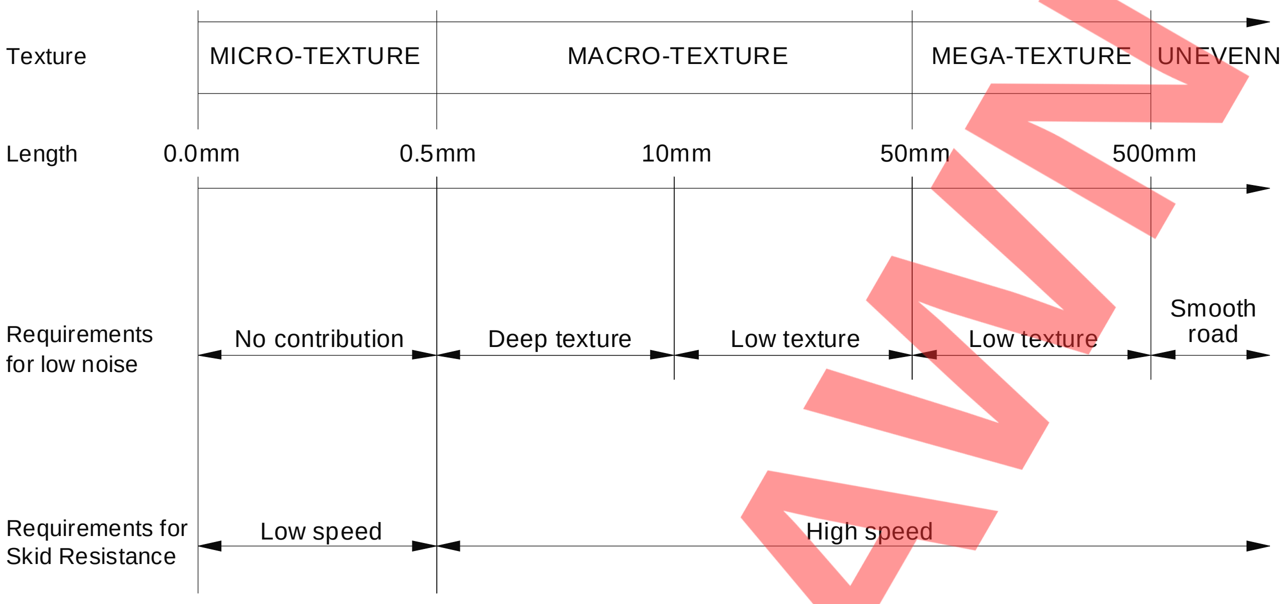

Figure 5.2 Effects of texture depths on skidding and noise

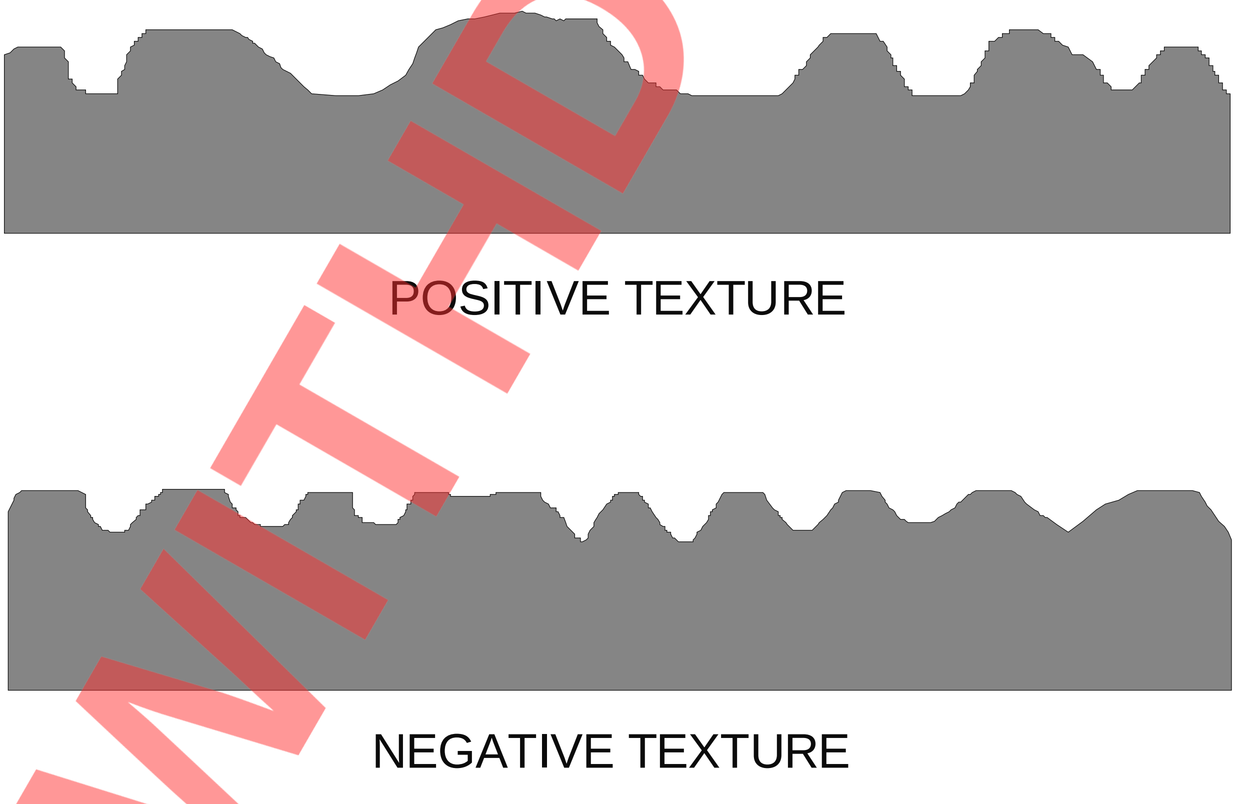

Figure 5.3 Details of surface with positive or negative texture

Macrotexture

5.14 Macrotexture amplitudes on surface dressed and HRA roads come from the space between individual stones. This is a factor of the size and the evenness of the stones on the surface of the road. With PA, thin surfacing and EACS the macrotexture depths are dependant on the shape of the aggregate at the surface and the voids between adjacent stones. The voids between the stones allow the air and water beneath the tyre to dissipate rather than be trapped. The cubic nature of stone with a low flakiness index enables a flatter surface of stone to be presented at the road surface with the benefits outlined in para 5.10. Water trapped between the tyre and the road causes aquaplaning at high speed and trapped air causes noise when the pressure is released. At larger lengths of macrotexture vibrations in a tyre wall, which are a significant cause of tyre noise, are excited. The ideal is to produce a macrotexture with high depths in the 0.5 to 10mm lengths and low depths in the 10 to 50mm lengths.

5.15 The texture of traditional concrete roads is formed by transverse brushing the surface of the concrete while it is still plastic. The aim is to produce an even texture without occasional transverse ridges. The bristles form the macrotexture during the transverse brushing operation. Too deep a texture depth can be formed by brushing when the concrete surface is either too wet, the brush pressure is incorrect or the bristles are of an inappropriate stiffness. A mix that has lost its workability or brushes that are clogged with mortar can produce a shallow texture.

5.16 With EACS, porous asphalt and thin surfacings the macrotexture is a function of the packing and size of the surface aggregate. A low flakiness index is specified to obtain more cubic aggregate which packs closely together to produce small voids. In the UK a 10 to 6mm coarse aggregate with a 1.5mm texture depth has been selected to provide adequate skidding resistance. In Austria an 8mm maximum sized aggregate was used to reduce the macrotexture in the texture range >10mm, and achieve good noise reducing properties. An 8 to 4mm sized aggregate with a 1.0mm texture depth is recommended for lower speed roads (90km/hr) where the risk of aquaplaning is less than for high speed roads.

5.17 Porous asphalt and some thin surfacings have voids that interconnect with the surface. The voids permit water to drain to below the running surface of the road thereby giving these surfaces their spray reducing qualities. Noise entering these voids is to some extent trapped within the voids. The untrapped noise tends to be in the lower frequencies which gives these surfaces their more distinct lower tonal qualities. These surfaces tend to reduce both tyre/surface noise and engine/ transmission noise.

5.18 With voided surfaces the sand patch test does not give a true indication of the surface texture, or its potential lower noise properties, due to the sand partly entering the voids. The texture is better assessed by using close proximity laser based systems to determine the profile at the tyre contact surface. It has been found that the noise increases as the hydraulic conductivity reduces, indicating that the less porous surfaces give higher noise levels. The test for hydraulic conductivity gives an indication of the noise reducing properties of porous surfaces.

Megatexture

5.19 It has been found that high megatexture depths cause a tyre wall to deflect and vibrate under load. This is a major cause of tyre/road noise. Megatexture on HRA surfaces comes from gaps between the groups of chippings. This can be caused by the way the chipper spreads the chippings. The chipper dispenses chippings as a series of transverse bands, with the possibility of gaps between those bands. These gaps are often in the high macrotexture to megatexture ranges (> 10mm). If HRA surfaces are allowed to cool excessively, such that the chipping are not properly embedded, high depths of macrotexture and megatexture can result.

5.20 Concrete surfaces laid with a slipform or fixed form paver may have megatexture undulations caused by the paver. These arise from the natural irregularities of the paver method of working. There are slight vertical movements in the surfacing whenever the paver stops and starts, or the machine compensates for level changes. The vertical movements of the transverse finishing screed combined with the forward movement of the paver can cause regular depressions in the megatexture range. These can be reduced by the longitudinal oscillating float (super smoother) which gives the surface a final smoothing.

Conclusion

5.21 When examining the causes of tyre/road noise it is important to be aware of the various interacting factors. The aggregate at the surface makes a significant contribution to both the skidding and noise performance of the road. The construction techniques, that are under the control of the contractor, also provide a major contribution to the safety and the tyre/noise generated by the surface.

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