VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE

SECTION 5 PAVEMENT MATERIALS

PART 1

HD 36/06

SURFACING MATERIALS FOR NEW AND MAINTENANCE CONSTRUCTION

SUMMARY

This revision primarily updates Chapter 3 of this Standard. 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

1. Remove Contents pages from Volume 7 and insert new Contents pages for Volume 7 dated November 2006.

2. Remove HD 36/99 from Volume 7, Section 5 which is superseded by this Stadard and archive as appropriate.

3. Insert HD 36/06 into Volume 7, Section 5.

4. Please 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

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THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Surfacing Materials for New and Maintenance Construction

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PART 1

HD 36/06

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 and should be read in conjunction with HD 28 (DMRB 7.3.1). This Part also includes details of surface texture and how this affects surface noise at the tyre/road interface.

1.2 Supplementary information on bituminous materials is given in HD 26 (DMRB 7.2.3). Further information on the maintenance of bituminous roads can be found in HD 31 (DMRB 7.4.1) and in HD 32 (DMRB 7.4.2) for the maintenance of concrete roads.

1.3 Detailed information on bituminous material types, and surfacing processes, together with advice on their 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

1.4 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

1.5 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, are safe and give value for money. For many years hot rolled asphalt with chippings rolled into the surface was the most widely used surfacing on trunk roads, including motorways, for both new construction and major maintenance. However, recent years have seen the development of new materials and techniques, many of which are proprietary, which 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 that are now available for both new construction and maintenance.

Performance Specifications

2.2 To remove the 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), high friction surfacing (Clause 924), (Clause 938), thin surface 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 under the British Board of Agrément Highway Authorities Product Approval Scheme (BBA HAPAS).

2.3 Where BBA HAPAS certification is specified but certificates are not in place, or in England, HA type approval has not been given, the approval of the Overseeing Organisation must 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 for use on trunk roads, 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 The decision on which permitted options are to be included should be made on a site-specific basis but none should be ruled out without justification. In locations where speeds are limited and tyre/road generated noise low, or where traffic intensity and therefore the overall noise level is not very great, then the full range of suitable surfacings should be considered

2.6 Where noise levels are high due to the intensity of high-speed traffic, surfacing materials are available that can significantly reduce tyre/road generated noise emission compared to hot rolled asphalt. These include hot, paver-laid thin surface course systems, Specification Clause 942 (MCHW 1).

2.7 Advice on the different types of surfacings is given in HD 37 and 38 (DMRB 7.5.2 & 3). Although information on various surfacings and treatments is provided in HD 37 and HD 38, it should not be assumed that their use is permitted on the trunk road network. Advice is provided for certain treatments for information only. Reference should be made to Table 2.2 to check permitted options.

2.8 In England, no surface treatment should be considered without taking into account the Highways Agency's requirements for low-noise surfacing. Retexturing of existing surfaces is not permissible without Departure approval. This approval will not be unreasonably withheld for small lengths of pavement with a particular skidding or other safety concern.

2.9 The surfacing options permitted shall be those shown in Tables 2.2E, 2.2NI and 2.2W, for England, Northern Ireland and Wales respectively. Where an option is permitted with "Departure Required", a Departure from Standard will be required from the Overseeing Organisation.

For Table 2.2S, for use in Scotland, where an option is permitted subject to "Approval to Proceed", such approval is required from the Overseeing Organisation.

2.10 In Table 2.2, high-speed roads are defined as those with an 85th percentile traffic speed exceeding 65 km/hr. The various pavement construction types are defined in HD 26 (DMRB 7.2.3).

England

All construction types

This table is for use in England only

				Use without restriction	Departure required
New Construction or Major Maintenance?	Yes			Thin Surface Course System	Porous Asphalt
	No (minor)	High speed? (85%ile above 65 km/hr)	Yes	Thin Surface Course System	Hot Rolled Asphalt Porous Asphalt Surface Dressing Exposed Aggregate Concrete (note 1) Brushed/Burlap Drag/Tined Concrete (note 1)
			No	Thin Surface Course System	Hot Rolled Asphalt Porous Asphalt Surface Dressing Slurry/Microsurfacing Exposed Aggregate Concrete (note 1) Brushed/Burlap Drag/Tined Concrete (note 1)

Note 1: Rigid construction only

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

Wales

All construction types

				Use without restriction	**Departure required**
New Construction or Major Maintenance?	Yes			Thin Surface Course System	Hot Rolled Asphalt Porous Asphalt Exposed Aggregate Concrete (note 1)
	No (minor)	High speed? (85%ile above 65 km/hr)	Yes	Thin Surface Course System	Hot Rolled Asphalt Porous Asphalt Surface Dressing Exposed Aggregate Concrete (note 1) Brushed/Burlap Drag/Tined Concrete (note 1)
			No	Thin Surface Course System	Hot Rolled Asphalt Porous Asphalt Surface Dressing Slurry/Microsurfacing Exposed Aggregate Concrete (note 1) Brushed/Burlap Drag/Tined Concrete (note 1)

Note 1: Rigid construction only

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

Scotland

All construction types

				Use without restriction	**Approval to Proceed required**
New Construction or Major Maintenance?	Yes			Hot Rolled Asphalt (note 1)	Thin Surface Course System Porous Asphalt Generic SMA Exposed Aggregate Concrete (note 3)
	No (minor)	High speed? (85%ile above 65 km/hr)	Yes	Hot Rolled Asphalt (note 1)	Thin Surface Course System Porous Asphalt Surface Dressing Generic SMA Exposed Aggregate Concrete (note 3) Brushed/Burlap Drag/Tined Concrete (note 3)
			No	Hot Rolled Asphalt (note 2) Surface Dressing	Thin Surface Course System Porous Asphalt Generic SMA Slurry/Microsurfacing Exposed Aggregate Concrete (note 3) Brushed/Burlap Drag/Tined Concrete (note 3)

Note 1: Not permitted on rigid construction
Note 2: Refer to Overseeing Organisation on rigid construction
Note 3: Rigid construction only

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

Northern Ireland

Flexible and flexible composite

				Use without restriction	Departure required
New Construction or Major Maintenance?	Yes	High speed? (85%ile above 65 km/hr)	Yes	Thin Surface Course System Hot Rolled Asphalt	Porous Asphalt (note 1)
			No	Thin Surface Course System Hot Rolled Asphalt Coated macadam	Porous Asphalt (note 1) Generic SMA
	No (minor)	High speed? (85%ile above 65 km/hr)	Yes	Thin Surface Course System Hot Rolled Asphalt Surface Dressing	Porous Asphalt (note 1)
			No	Thin Surface Course System Hot Rolled Asphalt Coated macadam Surface Dressing Slurry Surfacing	Porous Asphalt (note 1) Generic SMA

Note 1: not permitted on flexible composite construction

Rigid

				Use without restriction	Departure required
New Construction or Major Maintenance?	Yes	High speed? (85%ile above 65 km/hr)	Yes	Exposed Aggregate Concrete	Brushed Concrete Burlap Drag Concrete Tined Concrete
			No	Exposed Aggregate Concrete	Brushed Concrete Burlap Drag Concrete Tined Concrete
	No (minor)	High speed? (85%ile above 65 km/hr)	Yes	Exposed Aggregate Concrete Hot Rolled Asphalt Surface Dressing	Brushed Concrete Burlap Drag Concrete Tined Concrete Porous Asphalt Thin Surface Course System
			No	Exposed Aggregate Concrete Hot Rolled Asphalt Surface Dressing Slurry Surfacing	Brushed Concrete Burlap Drag Concrete Tined Concrete Porous Asphalt Thin Surface Course System Generic SMA

Rigid composite

				Use without restriction	Departure required
New Construction or Major Maintenance?	Yes	High speed? (85%ile above 65 km/hr)	Yes	Hot Rolled Asphalt Thin Surface Course System	Porous Asphalt
			No	Hot Rolled Asphalt Thin Surface Course System Surface Dressing	Porous Asphalt
	No (minor)	High speed? (85%ile above 65 km/hr)	Yes	Hot Rolled Asphalt Thin Surface Course System	Porous Asphalt Generic SMA
			No	Hot Rolled Asphalt Thin Surface Course System Surface Dressing Slurry Surfacing	Porous Asphalt Generic SMA

Table 2.2NI (N Ireland): Permitted Pavement Surfacing Materials for New and Maintenance Construction

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3. TEXTURE AND AGGREGATE 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 the tyre and road surface, and tyre resilience are important factors in determining wet skidding resistance at high speeds. Annex 3 of HD 28 (DMRB 7.3.1) contains further discussion of skid resistance and the influence of micro- and macro-texture. **Megatexture** relates to the roughness of the road and has no effect on skidding resistance but affects noise, (see Chapter 5 of this Part for details).

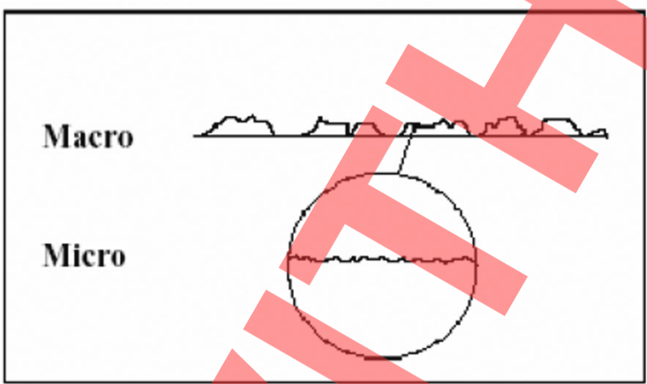

Figure 3.1: Surface Texture

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, must be carried out and is specified in BS EN 1097-8:2000. It requires six 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) must used to determine the skid resistance value of the aggregate after polishing. This is termed the PSV.

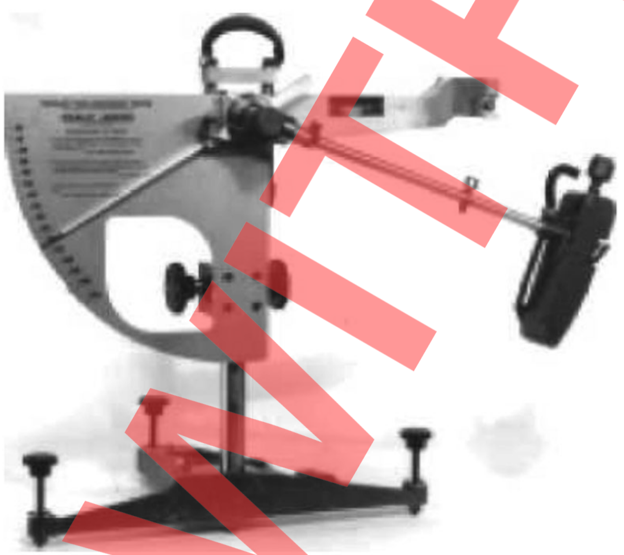

Figure 3.3: Portable Skid Resistance Tester

3.9 Aggregate durability must be measured by the Aggregate Abrasion Value (AAV) test as defined in Annex A of BS EN 1097-8:2000. 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 must 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 motorways carry in excess of 6000 commercial vehicles per lane per day, PSVs in excess of those shown in Table 3.1 must not be specified. Although minimum PSV values have been included for all types of site and traffic level, some combinations are unlikely to occur in practice.

Site category	Site description	IL	Minimum PSV required for given IL, traffic level and type of site — Traffic (cv/lane/day) at design life: 0-250	251-500	501-750	751-1000	1001-2000	2001-3000	3001-4000	4001-5000	5001-6000	Over 6000
A1	Motorways where traffic is generally free-flowing on a relatively straight line	0.30	50	50	50	50	50	55	55	60	65	65
		0.35	50	50	50	50	50	60	60	60	65	65
A2	Motorways where some braking regularly occurs (eg. on 300m approach to an off-slip)	0.35	50	50	50	55	55	60	60	65	65	65
B1	Dual carriageways where traffic is generally free-flowing on a relatively straight line	0.3	50	50	50	50	50	55	55	60	65	65
		0.35	50	50	50	50	50	60	60	60	65	65
		0.4	50	50	50	55	60	65	65	65	65	68+
B2	Dual carriageways where some braking regularly occurs (eg. on 300m approach to an off-slip)	0.35	50	50	50	55	55	60	60	65	65	65
		0.4	55	60	60	65	65	68+	68+	68+	68+	68+
C	Single carriageways where traffic is generally free-flowing on a relatively straight line	0.35	50	50	50	55	55	60	60	65	65	65
		0.4	55	60	60	65	65	68+	68+	68+	68+	68+
		0.45	60	60	65	65	68+	68+	68+	68+	68+	68+
G1/G2	Gradients >5% longer than 50m as per HD 28	0.45	55	60	60	65	65	68+	68+	68+	68+	HFS
		0.5	60	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS
		0.55	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS
K	Approaches to pedestrian crossings and other high risk situations	0.5	65	65	65	68+	68+	68+	HFS	HFS	HFS	HFS
		0.55	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS
Q	Approaches to major and minor junctions on dual carriageways and single carriageways where frequent or sudden braking occurs but in a generally straight line.	0.45	60	65	65	68+	68+	68+	68+	68+	68+	HFS
		0.5	65	65	65	68+	68+	68+	HFS	HFS	HFS	HFS
		0.55	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS
R	Roundabout circulation areas	0.45	50	55	60	60	65	65	68+	68+	HFS	HFS
		0.5	68+	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS
S1/S2	Bends (radius <500m) on all types of road, including motorway link roads; other hazards that require combined braking and cornering	0.45	50	55	60	60	65	65	68+	68+	HFS	HFS
		0.5	68+	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS
		0.55	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS

Notes:

1. Site categories are grouped according to their general character and traffic behaviour. The Investigatory Levels (IL) for specific categories of site are defined in HD 28 (DMRB 7.3.1). The IL to be used here must be that which has been allocated to the specific site on which the material is to be laid, as determined by following the procedures in HD 28.
2. Motorway or dual carriageway slip roads may fit in a number of groups depending on their layout. For example, a free-flowing section close to the main line would be in Group 1 whereas the end of an off-slip approaching a give way line or the point at which a queue develops would be in Group 3. Some slip roads with gradients may be in Group 4. Use the most appropriate Group depending upon the Site Category from HD 28 that was used to determine the IL.
3. Where '68+' material is listed in this Table, none of the three most recent results from consecutive PSV tests relating to the aggregate to be supplied must fall below 68. See paragraph 3.21.
4. Throughout this Table, HFS means specialised high friction surfacing, incorporating calcined bauxite aggregate and conforming to Clause 924 of the Specification (MCHW 1) will be required. Where HFS is required on the approaches to a hazard, the minimum treatment length must be 50m. This may be extended where queuing traffic or sightlines indicate that 50m may not be sufficiently long.
5. For site categories G1/G2, S1/S2 and R any PSV in the range given for each traffic level may be used for any IL and should be chosen on the basis of local experience of material performance. In the absence of this information, the values given for the appropriate IL and traffic level must be used.
6. Where designers are knowledgeable or have other experience of particular site conditions, an alternative psv value can be specified.

Table 3.1: Minimum PSV of Chippings, or Coarse Aggregate in Unchipped Surfaces, for New Surface 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 surface course systems, exposed aggregate concrete surfacing and coated macadam surface 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 Surface Courses

3.13 The PSVs in Table 3.1 are related to the IL for different traffic flows set out in Chapter 4 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 junctions, on bends 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.

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 Characteristic SCRIM Coefficient. See Chapter 4 of HD 28 (DMRB 7.3.1).

3.15 The traffic flow used to determine the appropriate PSV and AAV for a particular surfacing must 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) predicted 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 must 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 skid resistance on sites of average difficulty requiring the given investigatory level within the general site group for the life of the surfacing.

3.18 For site categories G1/G2, S1/S2 and R a range of ILs and corresponding PSVs for each traffic level is given in Table 3.1. For sites in these groups, the PSV to be specified should be based upon local experience of material performance. For maintenance resurfacing, the current skid resistance in relation to the life achieved, the investigatory level and the skidding accident rate should be considered. If satisfactory, the PSV and AAV of the new surfacing should be the same as the aggregates used previously. If considered unsatisfactory, the PSV must be increased to that for a higher IL within the range given for the appropriate traffic level. For new construction, existing sites with similar traffic flows, IL and site geometry 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 values given for the appropriate IL and traffic level must be used.

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 must 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 surface course systems, porous asphalt, bitumen macadam surface courses and surface courses of rolled asphalt 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; and

e) the coarse aggregate in non-surface dressed binder courses of bitumen macadam or stone mastic asphalt and bases 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 aggregate representative of those to be incorporated into the Works must be tested in accordance with BS EN 1097-8 for compliance with the specified PSV and AAV properties. Alternatively, except where a PSV of 68+ is specified, the aggregate must be deemed to comply if the mean of the three 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 six months by a laboratory accredited by UKAS or equivalent for these tests or by a laboratory in a Member State of the European Economic Area or a State which is party to a relevant agreement with the European Union that can demonstrate suitable and satisfactory evidence of technical and professional competence and independence for such tests. The latter requirement must be satisfied if the laboratory is accredited in a Member State of the European Economic Area or a State which is party to a relevant agreement with the European Union in accordance with the relevant parts of EN45000 series of standards for the tests carried out.

3.22 It is essential that the aggregate supplied to site must 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, further tests must be ordered.

3.23 There are few quarries that can supply aggregate where 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 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 volumetric patch test). Therefore, on high speed roads, this type of material must 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 must 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 NG 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 (>65km/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, hot rolled asphalt with chips, slurry and microsurfacings and brushed concrete;

b) 'negative' texture: a network of depressions or series of grooves below the general level, typical of thin surface course systems, and porous asphalt.

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

3.29 For speeds in excess of 65km/h, the texture depth of the surface should be that required by the Specification (MCHW1). This will ensure that the decrease in skid resistance that occurs at higher speeds is minimised and will 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 depth 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 PSV.

Measurement

3.30 For many years texture depth has been measured by the volumetric patch method in which a known volume of solid glass spheres or 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. The technique is described in BS EN 13036-1:2002.

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

The Measurement of Texture at High Speed

3.32 It is possible to measure texture indirectly using lasers and reflected light at speeds up to 100km/h. This method has been incorporated in a number of devices including the SCRIMTEX, the Highways Agency research tool HARRIS (Highways Agency Road Research Information System: Figure 3.5) and Traffic Speed Condition Surveys (TRACS).

Figure 3.5: Highways Agency Road Research Information System (HARRIS)

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 they 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

Describes 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 and brushed concrete), or the depth of texture below the road surface (eg. for porous asphalt, thin surfacings, tined and exposed aggregate concrete surfaces, (EACS)).

iii) Megatexture

Represents the degree of smoothness of the surface.

iv) Unevenness

Describes amplitudes of longer wavelengths, which affect vehicle suspensions.

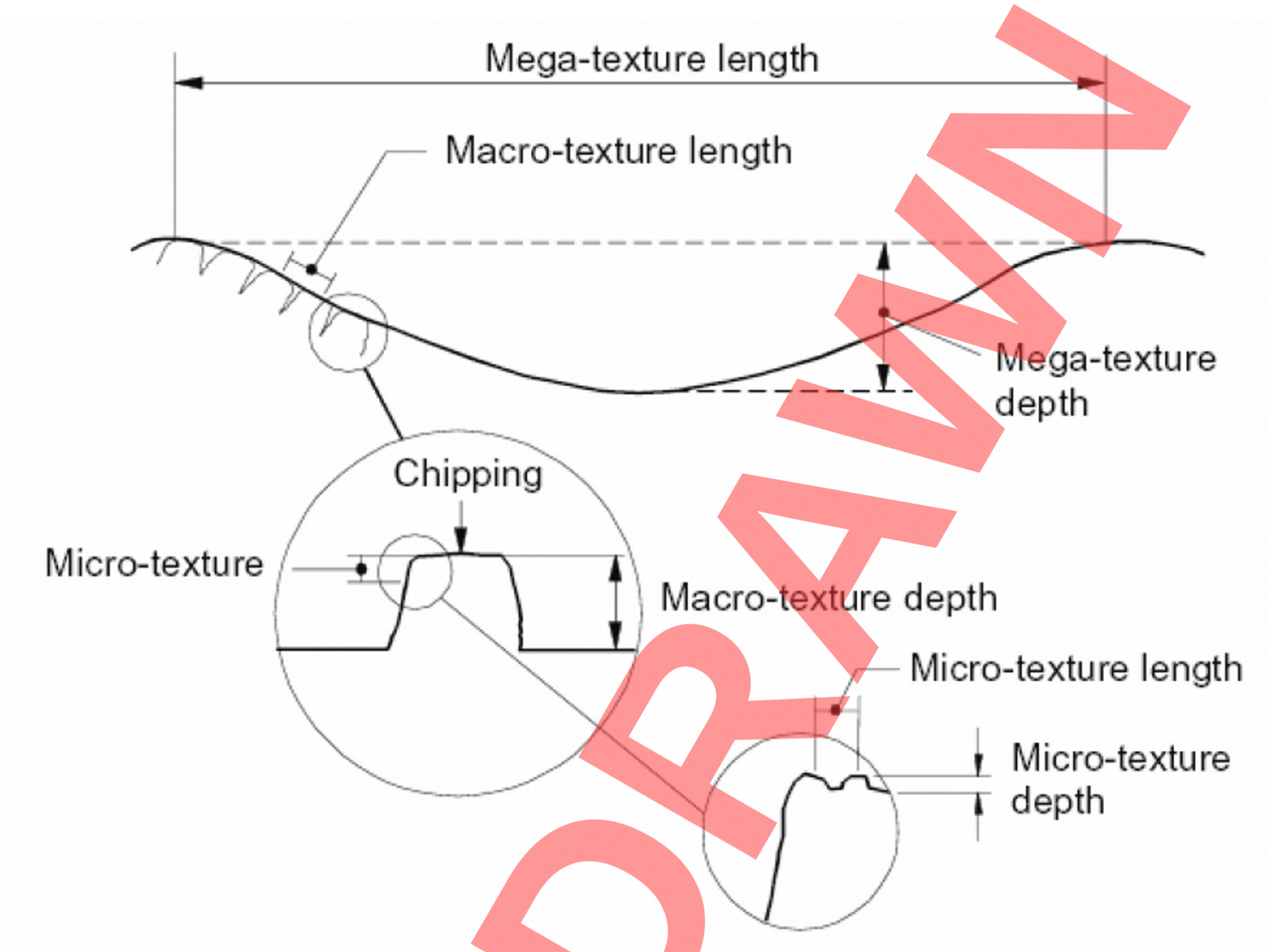

Figure 5.1: Details of Texture Length and Depths

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 interrelationship of the effects of different types of texture on skidding resistance and noise generation are shown in Figure 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 that 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, leaving voids that 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).

Range	Texture length (mm)	Texture depth/ noise properties	Skidding resistance
Micro texture	<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

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.

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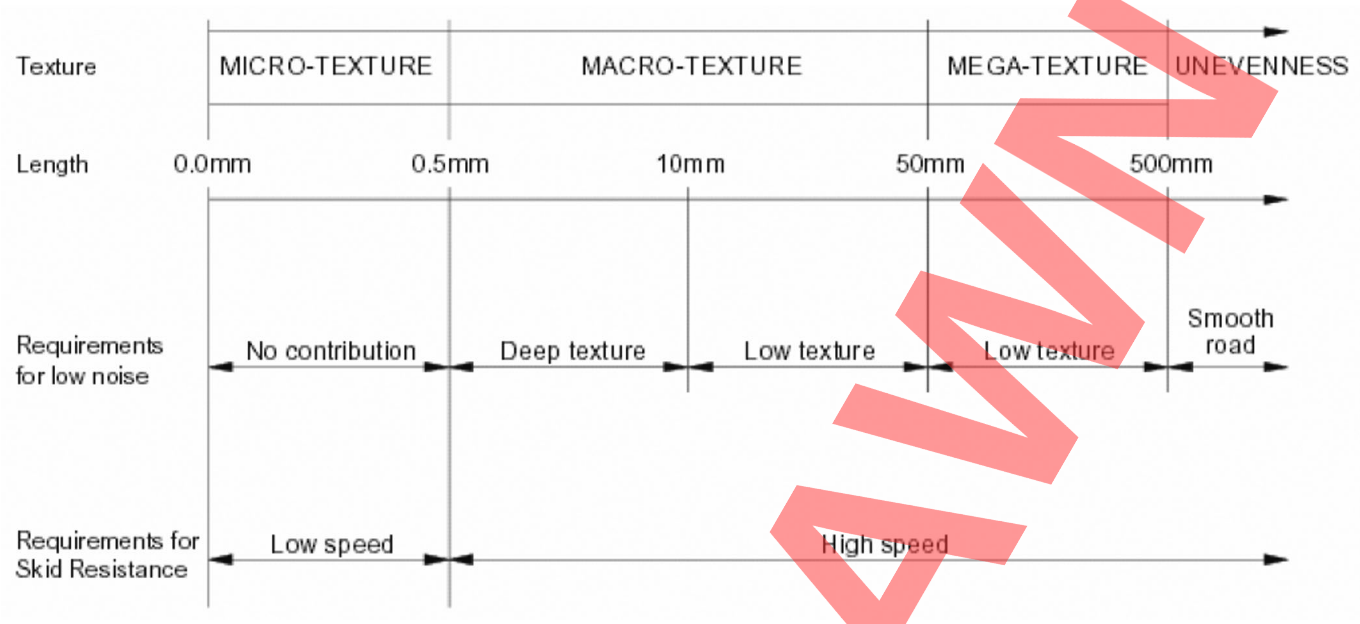

Figure 5.2: Effects of Texture Depth on Skidding and Noise

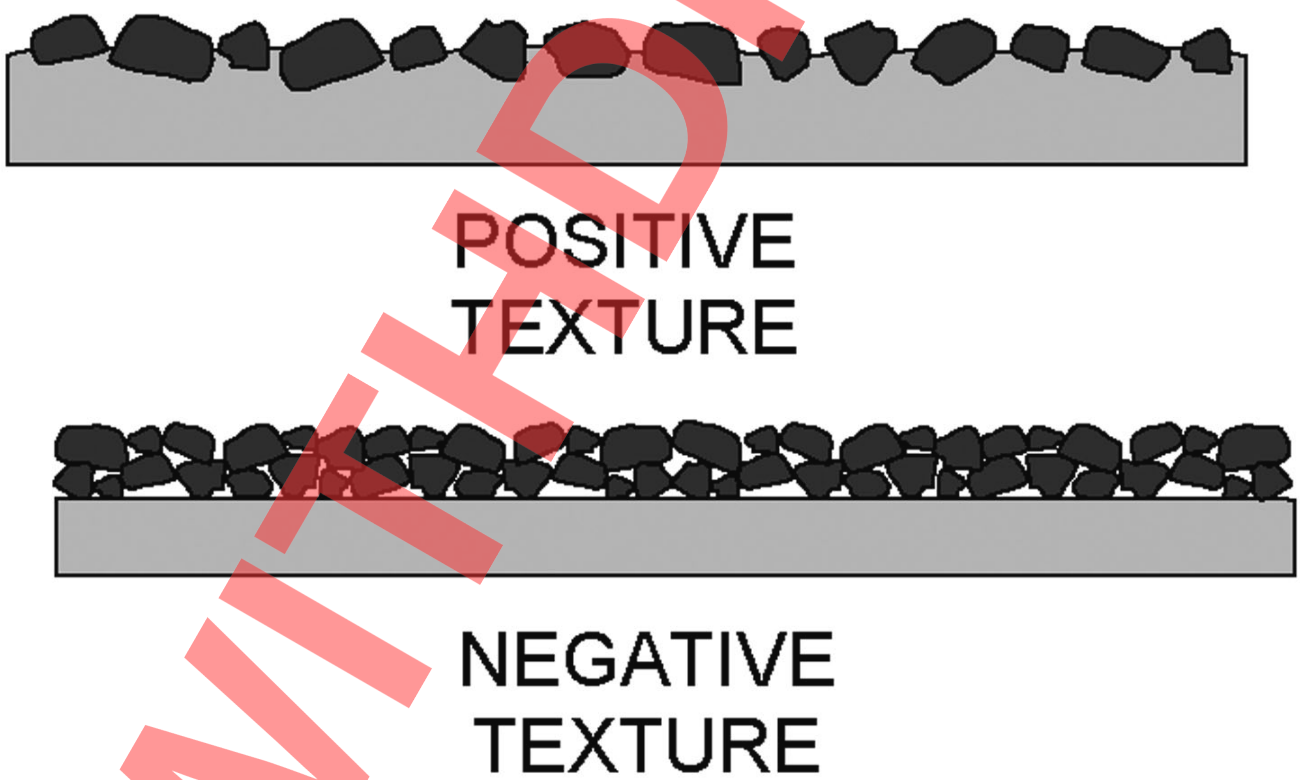

Figure 5.3: Details of Surface with Positive or Negative Texture

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 surfacings 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 paragraph 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. Brushing when the concrete surface is either too wet, the brush pressure is incorrect or the bristles are of an inappropriate stiffness can form too deep a texture depth. 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 that 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 that give 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 chippings 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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