VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE
SECTION 5 SURFACING AND SURFACING MATERIALS

PART 3

HD 38/97

CONCRETE SURFACING AND MATERIALS

Amendment No. 1

SUMMARY

This amendment includes completely revised Chapters 1 and 6 and new Chapters 2 and 4 dated February 1999.

INSTRUCTIONS FOR USE

1. Insert the replacement pages listed on the Amendment sheet (Amendment No. 1), removing the corresponding existing pages which are superseded by this amendment and archive as appropriate.

2. Insert new Chapters 2 and 4.

3. Enter details of Amendment No. 1 on the Registration of Amendments sheet, sign and date to confirm that the amendment has been incorporated.

4. 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.

AMENDMENT No. 1 (February 1999)

Replacement Pages

Page No.	Date
Front sheet	
Contents page	
1/1 - Introduction (replaces 1/1)	February 1999
2/1 - 2/2 inc (new chapter)	February 1999
4/1 - 4/4 inc (new chapter)	February 1999
6/1 (replaces 6/1)	February 1999

Implementation

The replacement page should be used forthwith on all schemes for the construction, improvement and maintenance of trunk roads including motorways.

VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE

SECTION 5 SURFACING AND SURFACING MATERIALS

PART 3

HD 38/97

CONCRETE SURFACING AND MATERIALS

SUMMARY

This Standard gives advice on the materials and techniques available for road surfacing to trunk roads using concrete.

INSTRUCTIONS FOR USE

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

1. Insert HD 38/97 into Volume 7, Section 5.

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.

DESIGN MANUAL FOR ROADS AND BRIDGES

HD 38/97

Incorporating Amendments No. 1 dated February 1999

THE HIGHWAYS AGENCY

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

Concrete Surfacing and Materials

Summary: This Standard gives advice on the materials and techniques available for road surfacing to trunks roads using concrete.

VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE

SECTION 5 SURFACING AND SURFACING MATERIALS

PART 3

HD 38/97

CONRETE SURFACING AND MATERIALS

Amendment No. 1

Contents

Chapter

VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE

SECTION 5 SURFACING AND SURFACING MATERIALS

PART 3

HD 38/97

CONCRETE SURFACING AND MATERIALS

SUMMARY

This Standard gives advice on the materials and techniques available for road surfacing to trunk roads using concrete.

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

1. Insert HD 38/97 into Volume 7, Section 5.

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1. INTRODUCTION

General

1.1 This Part of the Design Manual for Roads and Bridges gives advice on the materials and techniques available for road surfacing to trunk roads using concrete. Similar advice relating to bituminous surfacing is found in HD 37 (DMRB 7.5.2).

1.2 This Part contains advice on providing a transverse textured concrete surface finish and an Exposed Aggregate Concrete Surface (EACS) which is also known as whisper concrete. Advice is also provided for retexturing a concrete pavement if there has been a loss of skidding resistance.

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.

2. Transverse Textured Concrete Surface

General

2.1 This Chapter explains the use of transverse textured concrete surface. It gives the background and details for the finish that will meet the requirements of the Specification for Highway Works (MCHW 1) Series 1000. This is achieved by transversely brushing or tining the slab after compaction of the concrete is completed and before commencement of the curing process. A brushed or tined surface finish may be applied to UnReinforced Concrete (URC), Jointed Reinforced Concrete (JRC) or Continuously Reinforced Concrete Pavements (CRCP).

2.2 Brushed concrete surfaces have been successfully constructed and have given many years of trouble free service, provided proper maintenance has been carried out. In recent years it has become evident that some brushed concrete surfaces can have high tyre/road noise levels. The advice given in this Chapter is aimed at ensuring that new surfaces are not excessively noisy whilst maintaining adequate skidding resistance. Further advice on the noise generated on concrete surfaces is given in HD 36 (DMRB 7.5.1).

Scope

2.3 The requirements for the materials and the construction of roads with a brushed concrete surface are given in the Specification (MCHW 1) Series 1000. The relevant Clause should be used in conjunction with the associated Appendix 7/1 and the related Notes for Guidance to the Specification for Highway Works (MCHW 2).

Use

2.4 For details of locations where brushed concrete is suitable, refer to HD 36 (DMRB 7.5.1).

Materials

Cements
2.5 Cements used for the construction of concrete pavements will be composed of Portland Cement (PC), often in combination with ground granulated blastfurnace slag (ggbs) or pulverised fuel ash (pfa).

2.6 The specified minimum cement contents have been shown to provide the concrete with satisfactory long term durability. The limits on ggbs and pfa have been set to give the concrete a resistance to spalling when subjected to de-icing salts.

Admixtures
2.7 To assist in maintaining the workability of high strength pavement quality concrete mixes, while keeping a low water/cement ratio, plasticisers and super-plasticisers are often used. Air entrainment is required in the top 50mm of a concrete pavement to provide resistance to surface scaling from de-icing salts.

Aggregates
2.8 The coarse aggregate will be natural material, crushed concrete or air-cooled blast furnace slag. The soundness value will exceed 75 and the maximum size will be 40mm, unless the spacing of the longitudinal reinforcement is less than 90mm, when it will not exceed 20mm.

2.9 The use of white flints is not advised. They can cause pop-outs or can lead to D-shaped cracking. They consist of nodules of cortex or harder flints covered in cortex. Cortex is weathered flint and is porous as are, to some extent, all flint aggregates. The overall porosity of a flint aggregate will depend on the proportion of white flints. Smaller particles tend to have higher adsorption than larger aggregate sizes.

2.10 The acid soluble content of the fine aggregate (sand) is limited to ensure the surface has satisfactory low speed skidding resistance.

Construction

2.11 For a number of years new concrete pavements have been built in both single and 2 layer construction both of which are permitted by the Specification (MCHW 1) Series 1000. The Contractor may choose the method of construction. More recently 2 layer construction has been used with either 2 separate pavers or a double-decker paving machine. The advantage of 2 layer construction is that only the top layer needs to be air entrained and the lower layer can contain the higher levels of ggbs or pfa and sands with a higher acid soluble content.

2.12 Both fixed form and slip formed pavers have been successfully used. Recent developments appear to have made slip forming more attractive to contractors due to their increased capacity and flexibility on site. Modern slip form pavers also have the capability of being able to be adapted for 2 layer construction.

Joints

2.13 Joints in concrete pavements have been found to be a frequent source of maintenance. In recent years steps have been taken to both improve the durability, hence the serviceability, and to reduce the number of joints. Now expansion joints are only required at run on slabs at the end of CRCP pavements and for the maintenance of an existing road with expansion joints. Elsewhere to improve durability transverse joints are to be sawn contraction joints. Longitudinal joints may be wet formed or sawn. The timing of sawing the hardened concrete is critical. If sawn too early the aggregate will be plucked out, if too late the concrete will have already cracked. With flint gravel aggregates in lower strength concrete pavements cracking may occur before sawing can begin, whereas in pavements of high early strength flint gravel concrete joints are more likely to be successfully sawn.

2.14 The spacing of joints in slabs may be increased by 20% if a coarse aggregate with a low coefficient of linear expansion, such as limestone, is used in the concrete slab. If 2 layer construction is used the increased joint spacing may be used if this aggregate is used throughout the lower layer.

Surface finish

Regularity

2.15 The regularity of the surface provides a major contribution to the rolling resistance of that surface and the noise generated by traffic. The micro-texture (dependant on the constituents of the concrete) contributes to the slow speed skidding resistance and sufficient macro-texture (as measured by the sand patch test) reduces aquaplaning at high speed. Both are essential to produce a safe road. Mega-texture is found to generate tyre/road noise. Both macro and mega-texture are controlled by the oscillating longitudinal float, which is also known as a ‘super smoother’. (For details of micro-, macro- and mega-texture see HD 36 (DMRB 7.5.1.5)

2.16 The oscillating longitudinal float is an integral part of the paving equipment, playing a vital role in ensuring that a smooth, flat slab is produced. Where the oscillating longitudinal float is part of a separate piece of equipment, as may be the case if rail mounted paving equipment is chosen, it is essential that it keeps close to the rest of the paving train so that it is working on the fresh concrete surface.

Texture

2.17 Macro-texture is applied to the surface of the slab to provide a path for water and air to be dissipated from under the tyres. Texture may be applied by brushing the surface or by dragging burlap and then tining the surface of the wet concrete. Whereas both treatments create suitable macro-textures they can also produce surfaces with high mega-textures, which are unacceptably noisy.

2.18 Brushed textures are applied transversely across the slab while the concrete is still plastic. It is important that the texture is applied evenly with no ridges being formed, particularly where the brush overlaps with previous passes. The pressure of the brush on the road needs to be uniform and consistent and the bristles kept clean to enable a satisfactory finish to be produced.

2.19 The burlap and tined surfaces are widely used in America and now can be used in the UK. The burlap (wet hessian) is dragged over the surface after it has been regulated to precondition the surface and give it a micro-texture. The tined texture is produced using similar equipment to that for applying brushed texture but with the brush head replaced by a head carrying the steel tines which is drawn transversely across the surface. The tines are 3mm wide and spaced apart at one third of those given for texturing hardened surfaces in the Specification (MCHW 1) Clause 1029. A trial length should confirm the actual spacing required for the particular materials and plant being used.

Curing

2.20 Immediately after completion of the texturing of the slab it should be cured as required by the Specification (MCHW 1) Clause 1027 to reduce initial surface thermal cracking. During the initial period the surface should be protected against precipitation, moisture loss, contamination and dispersal of curing agent to avoid damage to the surface of the slab.

3. EXPOSED AGGREGATE CONCRETE SURFACE

General

3.1 This chapter outlines the use of Exposed Aggregate Concrete Surface (EACS) formerly known as 'whisper concrete'. It draws attention to the design, specification, construction and life of the surface and contains guidance on its design, use and maintenance.

3.2 EACS can provide a long life road surface with lower traffic noise than traditionally surfaced roads, offering comparable skid resistance. The exposed aggregate top surface forms a matrix of interconnected paths below the plane running surface through which water can pass, to maintain a high speed skidding resistance, and assist in reducing tyre/road surface noise. There may be a slight reduction in spray generated by high speed vehicles.

3.3 The level of noise emitted at a tyre/road interface on EACS is generally higher than for porous asphalt but lower than for hot rolled asphalt, brushed concrete and surface dressed running surfaces offering comparable skid resistance. EACS is perceived to have better tonal qualities than conventional brushed concrete surfaces.

3.4 The appearance of EACS is similar to that of hot rolled asphalt with a surface picking up its colour from the exposed aggregate.

Scope

3.5 Clauses specifying requirements for material properties, testing, laying and exposing the aggregate are given in the specification (MCHW 1) Series 1000. The relevant clauses in the Specification should be used in conjunction with the associated Appendix 7/1 and the related Notes for Guidance to the Specification for Highway Works (MCHW 2).

Development

3.6 EACS was first trialled in Denmark and developed in Belgium with the aim of producing a safe, long life concrete running surface as an alternative to the conventional brushed finishes used previously. The technique has been successfully used since the 1970s and now EACS is the normal form of surface treatment to CRCP on major Belgian roads. In the late 1980s the environmental problems of tyre/road noise came to the fore in Austria. Anxious to find a low noise concrete road surface that would stand up to studded tyre use in winter, the Austrians refined the Belgian process, discovering that by reducing the size of the chippings in the coarse aggregate at the road surface the tyre/road noise levels could be substantially reduced. Consideration was given in Austria to full depth construction but this would have used large quantities of premium aggregate. Two layer construction was chosen to produce an economic solution. Now this is the normal form of EACS construction in Austria providing an economic, long lasting surface giving measurable noise reduction when compared with conventional concrete pavements. Other countries which have used the EACS include France, the Netherlands, Australia and the USA. Also in Sweden it has provided a durable surface that stands up to the use of studded tyres in the winter months. EACS roads in Austria were constructed using a smaller sized aggregate, with a lower skidding requirement than specified in the UK. To provide an adequate low and high speed skidding resistance a deeper texture depth and the appropriate aggregate size are specified. Other European countries, apart from Belgium, have chosen to use jointed concrete slabs whereas in the UK, CRCP construction has been used. However, the use of jointed concrete pavements (URC and JRC) are permitted options for use on trunk roads, including motorways.

Use

3.7 EACS can be used in any location, including heavily trafficked roads. In noise sensitive areas EACS may be the only permitted concrete surfacing option.

Durability

3.8 Concrete roads are structurally designed for a traffic life of forty years although the surface will normally require restoration of skid resistance at some point in its life. The special aggregate used in the top mix concrete is durable, with the minimum PSV and maximum AAV specified in Appendix 7/1 of the Specification (MCHW 1). Evidence from other countries indicates that no particular durability problems will be encountered. In the UK, the trials of EACS have endured a number of winters without any sign of distress.

Noise

3.9 EACS is designed to provide an adequate level of skid resistance, both at high and low speeds, as well as a low level of surface noise. Work by Descornet and Fuchs (1992) has identified the respective roles of micro, macro (see HD 23/94 (DMRB 7.1.1) Glossary of Terms) and megatexture in relation to tyre road noise. On low speed roads, microtexture, which depends on the roughness or harshness of the aggregate, is of prime importance. On higher speed roads, macrotexture created by procedures such as transverse brushing or exposing the aggregate plays an important role in reducing noise. Megatexture, the variations of amplitude of certain wavelengths in the 50 to 500mm range, is an undesirable irregularity. It can be a major cause of tyre/ road noise because it creates radial vibration of the tyre. Megatexture can originate during the course of construction in the form of corrugation or other surface irregularities. The use of the transverse finishing screed in advance of a longitudinal oscillating float as soon as the surface is laid, plays a vital role in eliminating these characteristics by constructing the aggregate surface in a level plane and hence resulting in noise reduction.

3.10 This type of surface typically exhibits noise reductions of around 2 dB(A) compared with conventional bituminous surfaces, and is the quietest concrete surface currently available. EACS can be used in noise sensitive areas.

Structural Capacity

3.11 Depending upon the requirements of the highway scheme EACS can be applied to Jointed Unreinforced (URC), Jointed Reinforced (JRC), and Continuously Reinforced (CRCP) pavements.

Relative Costs

3.12 At present EACS is in the region of 10% more expensive than a similar pavement with conventional brushed concrete finishes. In certain areas of the country EACS can be cheaper than conventional asphalt. Experience shows that concrete surfaces compare well with HRA surfaces when whole life cycle costs are taken into account.

Materials and Mixing

3.13 In two layer construction the Specification (MCHW 1) gives a wide choice of aggregates for the concrete in the lower layer. The Specification (MCHW 1) for EACS states that:

a) the coarse aggregate requirements are given in the Specification and Appendix 7/1 (MCHW 1). The coarse aggregate should comprise at least 60% of the fully compacted concrete (total mass of the constituents excluding water). Attention is drawn to the special grading and flakiness requirements of the Specification (MCHW 1);

b) sand should comply with Classification F of Table 5 in Clause 5.2 of BS 882 : (1983), except for the grading requirements contained in the Specification (MCHW 1). The reason for restricting the maximum sand fraction is to make certain that tyres maintain contact with the coarse aggregate, to ensure that the required level of skidding resistance is provided;

c) the type of cement used in the concrete should be limited to Class 42.5N/42.5R Portland cement as defined in the Specification (MCHW 1).

Batching and Transportation

3.14 It is important for the contractor to take steps to prevent the contamination of the concrete for EACS with aggregates or constituents for other concretes. Care should be taken in the stockpiling of materials. It is preferable that plant used for the batching and mixing of EACS should be separate from that used for other concrete.

3.15 Dedicated, clearly identified delivery vehicles should be used for the transport of the separate mixes. These should be cleaned thoroughly between deliveries of separate mixes. Open tipper trucks should be sheeted.

Construction

3.16 Two layer monolithic construction has been shown to be cost effective and has been successfully used by contractors. Rail mounted equipment has been used only in the UK. Elsewhere, slipform paving machines have been preferred. The requirements for all types of concrete for road pavements are given in the Specification (MCHW 1). The batching output capacity and transport delivery capacity should be sufficient to feed the paving equipment continuously, enabling a constant forward movement to be maintained during the period of paving.

3.17 The oscillating longitudinal float is an integral part of the paving equipment, playing a vital role in ensuring that a smooth, flat slab is produced prior to the application of retarder. Where the oscillating longitudinal float is part of a separate piece of equipment, as may be the case if rail mounted paving equipment is chosen, it is essential that it keeps close to the rest of the paving train so that it is working on the fresh concrete surface.

3.18 The exposure of the surface is a two stage process including retarding of the surface mortar, and brushing to expose the aggregate.

a) A suitable retarder should be used which will retard sufficiently the action of the cement at the surface of the top layer so that the target texture depth can be achieved by the brushing operation. Advice of retarder manufacturers should be sought. The retarder should contain a non staining dye, for visual identification of adequate coverage. The application system should atomise the retarder with a fine spray enabling total and even coverage of the slab to be obtained without overdosing with excess retarder flowing over the surface of the slab. From the time that the concrete surface is finished and the retarder is applied the surface of the concrete needs protection from both drying out and rainfall. The protection should be maintained until immediately before exposing the aggregate. This may be of a physical nature with protective sheeting being tightly stretched across the slab and firmly secured at the edges. (Such a process could require a licence to avoid infringement of a patent against which the contractor would indemnify the client as laid down in the Conditions of Contract). An alternative is a system of protection where a chemical substance, compatible with the retarder, is sprayed on to the newly retarded surface which, after some minutes, forms a protective skin which protects the retarder and slab against the elements. For this system temporary tentage is required to be available to protect the surface against rain before the longer term protection becomes operative.

b) The second stage in the creation of the exposed aggregate surface is the brushing. The time to start brushing requires careful judgement. Brushing too early will result in chipping loss, and brushing too late will mean the surface texture will be very difficult to achieve. The ideal surface will characteristically not only meet the target texture depth requirements, but also exhibit a 'shoulder to shoulder' pattern of chippings. Experience indicates that the more cubic the shape of the chipping, the more likely that close packing will occur.

3.19 Care should be taken to avoid fretting at day joints. This can be aggravated by retarder spray running down the vertical end of the slab. Hand finishing of the concrete can cause problems if excess grout is pulled to the surface, making exposure of the aggregate at this point more difficult.

3.20 Experience from the UK trials has shown that longitudinal joints can only be formed satisfactorily by sawing.

Surface Texture Depths

3.21 The required surface texture depths are stated in Appendix 7/1 in the Specification (MCHW 1). See also Table NG 10/3 in the Notes for Guidance (MCHW 2), which gives guidance on the requirements of average, maximum and minimum texture depths for high speed and low speed roads.

Brushing

3.22 The aggregate should be exposed by brushing in a longitudinal direction to give the texture depth as stated in Appendix 7/1 in the Specification (MCHW 1). Brushing should continue until that texture depth is achieved. Provision should be made for effective dust and laitance collection and disposal.

Curing

3.23 After brushing is completed the surface should be dampened prior to the application of the final curing agent.

Defect Repairs

3.24 If the specified minimum texture depth is not achieved by brushing, retexturing in accordance with Clause 1029 of the Specification (MCHW 1) should be carried out. Failure to achieve the specified minimum texture depths will result in unsatisfactory skid resistance for high speed vehicles and increased traffic noise of lower speed vehicles. The full extent of any areas still nonconforming following mechanical retexturing should be removed and replaced.

3.25 Where the specified average texture depth or the maximum texture depth is exceeded remedial measures should be agreed with the Overseeing Organisation.

3.26 Surface defects may be repaired provided:

a) The affected area is cut out to the top of the lower layer concrete;

b) A bonding agent is used; and

c) The same mix design used for the replacement concrete.

The aggregate should be exposed in such manner as to achieve a texture similar to that in an adjacent compliant slab.

Renewal of Skid Resistance

3.27 After a period of years it may be necessary to restore the skid resistance to the EACS. Research is continuing into satisfactory in-situ ways of carrying this out. Alternative methods of restoring the skid resistance include overlay or inlay technique using EACS or one of the thin bituminous surface treatments now available. Surface dressing, though possible, would almost certainly result in a sharp increase in tyre/road noise.

Winter Maintenance

3.28 There are no special winter maintenance requirements.

Road Markings

3.29 There are no problems associated with applying markings to an exposed aggregate surface.

4. Retexturing (Concrete)

4.1 The wet skidding resistance of a road is dependent on the tyre interacting with the microtexture of the road surfacing. On a concrete road, microtexture comes primarily from the sand and fine aggregate in the concrete surface layer. Microtexture is gradually polished by traffic until an equilibrium level of skidding resistance is reached. On a concrete road, the laitance containing the fine aggregate may be worn away to expose the coarse aggregate which may be unable to maintain adequate microtexture. HD 28 (DMRB 7.3.1) provides advice on standards for the skidding resistance of in-service roads.

4.2 The ability of a surface to maintain adequate skidding resistance at high speeds is governed by the macrotexture of the surfacing. As a surfacing ages, the level of macrotexture may fall as, for example, the ridges created by brushing, are worn away. There may also be inadequate or excessive brushing of the new concrete surface such that the minimum or maximum requirements for texture depth of a new road may not be met.

4.3 Retexturing is the mechanical reworking of a sound road surface to restore either skidding resistance, texture depth or both. However, on a concrete road the coarse aggregate may play a significant part in determining the suitability of retexturing treatments.

Retexturing techniques

4.4 The suitability and effectiveness of a retexturing treatment depends on the condition of the road prior to treatment. Some treatments can increase both skidding resistance and texture depth; others may increase skidding resistance but reduce texture depth. There are also treatments which increase texture depth with little effect on skidding resistance.

4.5 Advantages include:

a) conservation of natural resources by reworking an existing surface;

b) retexturing may be more economical than some traditional resurfacing methods especially where small areas are to be treated;

c) most processes can be carried out at any time of year in all but the most severe weather conditions;

d) traffic disruption is reduced compared with conventional treatments because of short lead-in times and the speed of the processes;

e) can be used as a “stop-gap” measure to treat small, high-risk sites.

4.6 Disadvantages include:

a) retexturing should not be used on unsound roads where there is cracking or surface irregularities, or on roads with sealing or overbanding;

b) caution is needed with some treatments where there are joints within the concrete surface. In some circumstances reinstatement of the joints may also be required;

c) road surfacing features such as ironwork, white lining and traffic detection loops may have to be avoided or protected;

d) retexturing is of limited value where the coarse aggregate has been exposed and that aggregate is easily polished;

e) some techniques may not be appropriate if the coarse aggregate is a very hard material such as flint, which may not respond well to impact or could cause damage or excessive wear to cutting blades.

4.7 The durability of the results of a treatment will depend on the type and geometry of road, the quantity and behaviour of the traffic. However, just as a new surfacing will polish under the action of traffic, a retextured concrete surface will eventually polish back to an equilibrium skidding resistance level, close to that of the original surfacing. On a high stress site, where there is much braking and turning, the improvement may last a matter of months but, on a low stress site, the same treatment may continue to show an improvement over the untreated surface for three years or more.

4.8 The following paragraphs give some comments on available methods and suggestions on their application for restoring skidding resistance and/or surface texture depth. Table 4.1 gives a summary of these methods and suggestions.

Impact methods

4.9 Processes in this category involve striking the road surface with either hard-tipped tools or hard particles. These treatments are effective where the loss of skidding resistance is due to polishing.

a) *Bush hammering*: The road surface is struck by a number of impact heads with chisel-ended hammers with hardened tips. This process enhances skidding resistance, regenerating the microtexture of the concrete surface by eroding the cementitious matrix. However, it can sometimes reduce texture depth, depending on the condition of the existing road surface and the severity of the treatment. In this process the force with which the road is struck can be controlled to some extent.

b) *shot blasting*: The impact is by steel shot projected at high speed from a rotating wheel. As the surface is scoured, both shot and arisings are recovered and separated, with the steel shot stored for reuse. This process improves skidding resistance by eroding the cementitious matrix to regenerate the microtexture of the concrete surface.

Cutting and scabbling/flailing

4.10 This category includes cutting, sawing, grooving, grinding and scabbling/flail grooving. In the latter case, the cutting action is combined with impact on the cutting heads.

a) *grooving/grinding*: Using diamond-tipped blades assembled in configurations to suit the patterns of cutting required. This process can be used to provide either discrete grooving patterns or for bump cutting. Transverse sawing of randomly-spaced grooves in hardened concrete, introduced in the Specification for Highway Works (Department of Transport, 1986), has been successfully used as a means of restoring macrotexture to worn or rain-damaged areas for a number of years. Grooving treatments can reduce macrotexture if the blades are in a close-spaced configuration. It should be borne in mind that microtexture is often unaffected by grooving because the plateaux between the grooves are the original surface.

b) *longitudinal scabbling*: Hardened tips set into the edges of steel washers are loosely mounted side-by-side and drawn across the road surface whilst being hydraulically loaded. This process enhances skidding resistance, by removing material from the tops of particles or ridges to expose new faces, but it can reduce surface texture depth by the same process. On a concrete road, this process may expose the coarse aggregate and this may not be appropriate where the aggregate has a naturally-polished surface (such as flint) or a low resistance to polishing, such as many limestones.

c) *orthogonal grooving*: This process is not recommended for concrete surfaces.

Fluid action

4.11 This involves the surface being subjected to the action of a fluid at high temperature or pressure. These treatments do not involve mechanical reworking of the road surface to expose new aggregate surfaces and, as a result, do not restore skidding resistance lost through the polishing action of traffic. However, they may have a scouring or cleaning action.

a) *hot compressed air*: This process scours the surface of the cementitious matrix removing material through dehydration of the cement paste and thermal shock.

b) *high pressure water jetting*: By using high pressure water to remove the residual tyre rubber detritus the original surface can be exposed.

Other considerations

4.12 Although retexturing is a useful option to consider when addressing problems of skidding resistance or surface texture depth loss due to the action of traffic, there will always be other factors to be taken into account.

a) Some treatments will be more appropriate for some surfaces than others. For example, an aggressive cutting or flailing technique would be inappropriate for a jointed surface where there is risk of the joints and the egdes of slab being damaged, with the accomanying risk of water ingress and frost action.

b) The effect of an individual process on both skidding resistance and texture depth must be considered in the light of what is required in a particular situation. For example, where surface texture is already at an acceptable level or where increasing it may be undesirable, a treatment that does not increase surface texture would be appropriate.

c) Retexturing is most effective on road surfaces which are generally sound. A surface which is worn or losing surface material may be damaged further by mechanical action.

4.13 The use of exposed aggregate concrete as a surface type is in its early stages in the UK, with no exposed aggregate surfacing having yet reached a level where remedial treatment is required. From a skidding resistance point of view, exposed aggregate concrete behaves in a similar way to asphaltic surfacings, in that it is the aggregate particles exposed at the surface which provide the microtexture. If retexturing techniques are to be considered for such surfacings, caution must be used to avoid loss of macrotexture due to excessive erosion of the exposed aggregate. There may be also a risk of aggregate loss if the supporting cementitious matrix is damaged.

4.14 As with all processes, the advice given here cannot cover all contingencies. It may be appropriate to take advice from suppliers regarding details of a particular process and its suitability for a particular site.

Surfacing type	Original condition: effect required from treatment		Suitability of treatment processes						
			Bush hammering	Shot blasting	Grooving/ grinding	Longitudinal scabbling	Orthogonal grooving	Hot compressed air	Water-jetting
CRCP	Polished surface: recovery of skidding resistance	good[1] texture	O	O	x	O	x	O	x
		poor[1] texture	O	O	x	O	x	O	x
	Brush-marks worn or rain-damaged: recovery of texture depth	good[2] SR	O	O	✔	O	x	x	x
		poor[2] SR	O	O	O	O	x	x	x
	Excessive noise/ excessive texture	good SR	✔	x	x	O	x	x	x
	Removal of oil/ rubber film	good SR	x	O	x	x	x	O	✔
Joint concrete pavement	Polished surface: recovery of skidding resistance	good texture	O	O	x	O	x	x	x
		poor texture	O	O	x	O	x	x	x
	Brush-marks worn or rain-damaged: recovery of texture depth	good SR	O	O	O	O	x	x	x
		poor SR	O	O	O	O	x	x	x
	Excessive noise/ excessive texture	good SR	O	x	x	O	x	x	x
	Removal of oil/ rubber film	good SR	x	x	x	x	x	O	✔
Exposed aggregate concrete	Polished aggregate: recovery of skidding resistance	good texture	✔	O	x	x	x	x	x
		poor texture	O	O	x	x	x	x	x
	Removal of oil/ rubber film	good SR	x	x	x	x	x	x	✔

Key:
- SR Skidding Resistance
- ✔ Appropriate treatment
- O Treatment may be appropriate in some circumstances but effects will be limited and depend on surfacing condition
- x Not recommended

Notes:

1 SMTD = Sensor Measured Texture Depth.
When referring to texture in this context, "good" and "poor" are approximately the following:
SMTD > 1.2 mm, good; SMTD < 0.6 mm, poor.

2 When referring to skidding resistance, "good" and "poor" denote above or below investigatory level respectively.

Table 4.1 Appropriate circumstances and treatments for retexturing concrete surfacings

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