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TII Publications

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Bituminous Mixtures, Surface Treatments, and Miscellaneous Products and Processes

DN-PAV-03024
June 2017

DN Design

Standards

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TII Authorisation and Contact Details

This document has been authorised by the Director of Professional Services, Transport Infrastructure Ireland. For any further guidance on the TII Publications system, please contact the following:

Contact: Standards and Research Section, Transport Infrastructure Ireland
Postal Address: Parkgate Business Centre, Parkgate Street, Dublin 8, D08 DK10
Telephone: +353 1 646 3600
Email: infoPUBS@tii.ie

TII Publications

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Contents

Updates to TII Publications resulting in changes to

Bituminous Mixtures, Surface Treatments, and Miscellaneous Products and Processes DN-PAV-03024

Date: June 2017

Amendment Details:

Chapter 8 of this Standard has been updated to incorporate advice and information in relation to determining the design of recipe surface dressing, and the requirements and performance of surface dressing product (end performance). The design requirements for recipe surface dressing have been introduced to Chapter 4 of DN-PAV-03074 Design of Bituminous Mixtures, Surface Treatments, and Miscellaneous Products and Processes.

Contents Table

1. Introduction

1.1 Scope

This Standard provides advice and information on the selection and properties of bituminous mixtures, surface treatments, and miscellaneous products and processes. A review is provided of the following products and processes.

a) Properties of Bituminous Materials

b) Bituminous Pavement Options

c) Hot Rolled Asphalt

d) Stone Mastic Asphalt

e) Porous Asphalt

f) Microsurfacing

g) Surface Dressing

h) High Friction Surfacing

i) Low Energy Bound Mixtures

j) Geotextiles and Geotextile Related Products and Materials

k) Retexturing of Bituminous Pavements

l) Permanent Repair Material Systems and Localised Surface Repair Systems

m) Emergency Repair Material Systems

1.2 Implementation

This Standard shall be used forthwith for all schemes for the construction, improvement and/or maintenance of National Roads projects, except where the scheme has received, prior to publication of this Standard, its statutory approvals to allow it to proceed. If this exception applies, the standard to be used may be either this current Standard or the Standard applicable preceding the June 2017 version of the Standard. Where the previous Standard is to be used, Design Organisations shall confirm this by e-mail to the Standards Section of Transport Infrastructure Ireland (TII) at infopubs@tii.ie.

The construction and maintenance of road pavements will normally be carried out under Contracts incorporating the Specification for Road Works Series 900 - Road Pavements - Bituminous Materials (CC-SPW-00900). In such cases works, goods or materials conforming to harmonised European Standards (hEN) where applicable will be acceptable in accordance with the terms of the Clauses 104 and 105 of CC-SPW-00900. Contracts that do not contain these clauses must contain suitable clauses of mutual recognition having the same effect. Advice should be sought in relation to such situations from TII's Head of Network Management.

Construction products must be supplied with appropriate CE marking in accordance with the Construction Products Regulation (CPR) or as required by CC-SPW-00900.

In order to allow a manufacturer of a construction product to draw up a declaration of performance for a construction product which is not covered or not fully covered by a harmonised standard, it is necessary to provide for a European Technical Assessment for these products. For more information on the implementation of the Construction Products Regulation in Ireland visit the Building Standards Section of the Department of Environment:

http://www.environ.ie/en/Publications/DevelopmentandHousing/BuildingStandards

1.3 Departures from Standards

In exceptional situations, TII may be prepared to agree to a Departure from Standards. Design Organisations wishing to consider pursuing this course shall discuss any such option at an early stage in design with TII Network Management. Proposals to adopt Departures from Standard must be submitted by the Design Organisation to TII and formal approval received BEFORE incorporation into a design layout.

2. Properties of Bituminous Materials

2.1 Introduction

This Chapter provides an introduction to bituminous binders followed by a review of the properties of bituminous materials including surface, base, binder and regulating courses.

2.2 Properties of Bituminous Binders

2.2.1 Conventional and Modified Binders

Bituminous binders play an important role in determining the properties of the bituminous material and conventional binders may be modified to improve performance of mixtures, when necessary, especially for the more heavily trafficked and highly stressed sections of the road network. With increasing commercial vehicle traffic volume, and increasing degree of site difficulty, the probability that modified binders will be needed increases as shown on Figure 2.1.

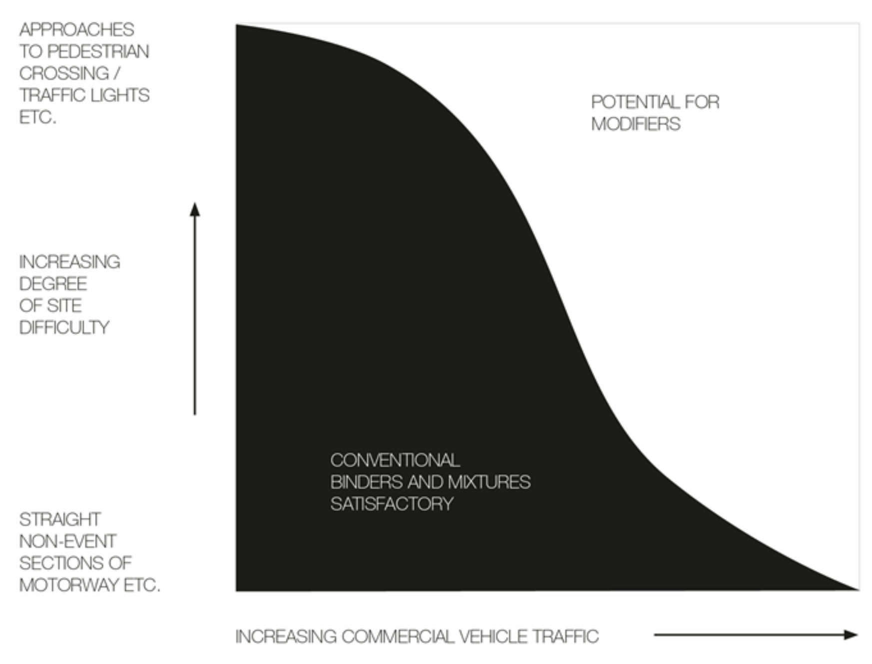

Figure 2.1: The Need for Modifiers in Mixtures at Difficult Sites and at High Traffic Volume

Benefits which may be obtained by the use of modified binders include:

a) Improved resistance to permanent deformation of mixtures at high service temperatures.

b) Greater load spreading (increased stiffness) for a pavement layer of given thickness.

c) Reduced fatigue of mixtures, giving reduced cracking under repeated load.

d) Improved ductility at low service temperatures, giving reduced thermal cracking.

e) Improved adhesion to aggregates, giving reduced stripping in mixtures and in surface dressings.

f) Increase cohesion, giving better chipping retention in the early lift of surface dressings.

g) Improved workability of mixtures, reducing the risk of poor compaction.

h) Reduced hardening or ageing in service, giving longer life in surface materials.

i) Reduced temperature susceptibility throughout service temperature range.

j) Increase viscosity at low shear rates, allowing thicker binder films to be obtained in open mixtures and reduced bleeding in surface dressings.

2.2.2 Properties of Binders

In general binders slowly harden with age and any binder showing unusually rapid hardening should be evaluated in the mixture.

One of the major requirements of the binder in a bituminous mixture is that it acts as an adhesive. To maintain mixture integrity, the binder must remain adherent to the aggregate in the presence of water and resist the effects of ageing. This adhesion is controlled by the interaction, at the molecular level, of the surface of the binder and the surface of the aggregate. Both binders and aggregates vary in their surface characteristics and it is important that when choosing a binder to coat a particular aggregate their compatibility is checked. As a rule, alkaline aggregates such as limestones are more tolerant of different binders than acid aggregates such as some granites, quartzites or flints.

It is a general requirement that the aggregate should be surface dry before attempting to coat it with bitumen. It is known that some aggregates ‘sweat’ in this condition and may need to be dried beyond the point of mere surface dryness before satisfactory long term adhesion can be achieved. Quartzite materials (which are a metamorphic rock) never fully dry during the heating before mixing because they retain a monomolecular, or thicker, layer of water on their surface.

Binder adhesion can be lost in the presence of water, because aggregate is hydrophilic and surface energy effects can cause stripping, especially if the binder is of low viscosity. With harder binders, the failure mechanism is associated with the balance of cohesion against adhesion. Thinner films of binder harden more rapidly with age and are likely to de-bond from the aggregate surface as cohesive forces and water displacement act together against adhesion.

The test specified to evaluate the effects of adhesion is the Water Sensitivity test, in accordance with IS EN 12697-12, which evaluates the ratio of the tensile strength between saturated and dry specimens. A further conditioning protocol is being developed and may be introduced as a standard test parameter in the future. The conditioning apparatus is known as the Moisture Induced Sensitivity Tester (MIST) and is currently specified in CC-SPW-00900 for use with products containing greater than 10% Reclaimed Asphalt.

For the mixture to be durable there must be sufficient cohesion (internal integrity) in the bitumen to enable the mixture to remain coherent under traffic stresses and induced strains for the life of the material. This life is usually in excess of the structural design life of the pavement.

Bitumen ages by hardening in the presence of oxygen, but it can only do so at, or close to, the surface of the bitumen film. Therefore, the thicker the bitumen film the longer it takes for the whole of the binder film to harden.

There is a limit to the amount of binder a mixture can hold; if too much binder is added, all the pores may be filled and a pore bitumen pressure could be developed, making the whole binder/aggregate matrix very unstable. Rutting can then occur under a relatively low number of load repetitions. To enable a high binder content to be used safely, the mixture as a whole must be designed to accommodate the binder, taking manufacturing tolerances into account.

2.3 Surface Courses

2.3.1 Introduction

Bituminous surface courses have a range of individual properties and careful selection of the material is required to match the material against the required functionality. Further guidance on this is provided in AM-PAV-06050 and DN-PAV-03074.

Bituminous surface course mixtures are manufactured in accordance with IS EN 13108. The materials are generally specified as either Asphalt Concrete (AC) in accordance with IS EN 13108-1, Hot Rolled Asphalt (HRA) in accordance with IS EN 13108-4 or Stone Mastic Asphalt (SMA) in accordance with IS EN 13108-5. Requirements for bituminous mixtures are specified in CC-SPW-00900.

2.3.2 Characteristics of Surface Courses

Key characteristics of surfacing materials are summarised in Table 2.1 for each of the main surfacing materials. Each parameter has been given a subjective ranking ranging from very low to very high compared to the other surfacing materials. A detailed discussion of each of the material properties is provided in the following Sections.

Table 2.1: Characteristics of Surface Courses

Characteristics	Surfacing Courses					
	Hot Rolled Asphalt (HRA)	Stone Mastic Asphalt (SMA)	Porous Asphalt	Micro surfacing	Surface Dressing (SD)	High Friction Surfacing (HFS)
Cost	High	High	High	Medium	Low	Very High
Environmental durability	High	Medium	Low	Medium	Medium	Low
Resistance to deformation	Medium	High	Medium	Medium	None	None
Load spreading ability	High	High	Low - Medium	None	None	None
Skidding resistance	High	High	High	Medium	High	Very High
Noise	Medium	Low	Low	Medium	Medium	Low
Impermeability	High	Medium	Very Low	Medium	High	Medium
Resistance to cracking	High	High	High	Medium	High	Medium
Ride quality	High	High	High	n/a	n/a	n/a

2.3.2.1 Cost

The cost of the applied treatments ranges from high cost (Hot Rolled Asphalt (HRA)) to low cost (Surface Dressing). The cost comprises the cost of supplying the product to site and the laying costs. These costs can vary greatly depending on the type of material, amount of material being laid and the proximity to the batching plant supplying the material.

2.3.2.2 Environmental Durability

This is the ability of a material to resist changes in its properties caused by environmental effects (such as rain, sun, frost, thaw, temperature changes, and oxidation) and also by contaminants deposited on the material (such as oil, mud and animal detritus). Long exposure will affect binders and the properties of the mixture, and may affect the aggregate. Durability may be assessed by measuring the changes in the engineering properties of the material with time.

A Water Sensitivity test can be carried out on bituminous mixtures which provides an indication of mixture durability using the ratio of the indirect tensile strength of wet (water conditioned) specimens to that of dry specimens.

The durability of a mixed material depends on either its ability to keep the weather out (if it is intended to be a dense material) or its ability to resist the weather (if it is permeable). A dense material should have an in situ void content of less than 6 %. The design void content will not be achieved without proper control of mixing, placing and compaction. The durability of open-graded and porous surface courses having interconnected voids (which permit the ingress and flow of air and water), depends on the thickness of the binder film on the aggregate, the susceptibility of the binder to oxidation, binder cohesion and the long term adhesion of the film to the aggregate. The durability of surface dressing and some of the bonded materials depends primarily on good adhesion to the underlying road structure.

Moisture damage, causing stripping of binder from the aggregate, leads to fretting and ravelling. The immediate cause is poor adhesion of the binder to the aggregate, which is usually related to the chemical composition of both aggregate and binder. Damage occurs more often with permeable, open graded materials, and the worst affected materials contain air void contents in the range 9-14 % which can neither drain nor dry out very easily.

2.3.2.3 Resistance to Deformation

This is important in all layers of a bituminous road, but the need is greater in the top 100mm of the pavement because:

a) The surface of a road gets hotter and the bitumen becomes softer compared to the lower layers.

b) The stresses generated by traffic are greatest at the surface.

Susceptibility to rutting can be measured by the wheel tracking test. In addition to the surfacing, it is also necessary for the binder course to be designed for resistance to deformation.

Bitumens harden over the first few weeks after laying and therefore a surfacing material is more prone to rutting during its very early life. Where heavy channelised traffic on new surfacing is likely to occur during the hottest period of the year it may be necessary to use a material with an enhanced resistance to deformation, such as one containing a polymer modified binder.

2.3.2.4 Load Spreading Ability

This is assessed by measuring the stiffness of the bituminous layers which make up the pavement. The following three situations need to be considered:

a) **New Construction**: The design charts in DN-PAV-03021 assume a minimum stiffness for the materials that will be used in the construction of a new road.

b) **Structural Strengthening of the Pavement**: Where structural strengthening of an existing pavement is being carried the load spreading ability of the pavement layers should be assessed in accordance with the guidance provided in AM-PAV-06050.

c) **Pavement Surface Treatment Options**: The strength or load spreading capacity of the surface course will generally be ignored for materials with a nominal layer thickness of 15mm or less.

2.3.2.5 Skidding Resistance

Skidding resistance is usually considered in the context of wet conditions. It is governed by the macrotexture of the pavement surface, which is related to the texture depth, and the microtexture of the stone touching the tyre which is measured by the Polished Stone Value (PSV). Skidding resistance is also influenced by the area of the tyre in contact with the road surface. Further information on these parameters and guidance on the selection of suitable values for each material is provided in DN-PAV-03023.

Texture depth can change with time, due to a number of different mechanisms. With surface dressing the main cause of this change is embedment of chippings into the underlying layer. Where compaction during laying is inadequate, asphalt materials will undergo secondary compaction under traffic, particularly in very hot weather. Very high macrotexture is not desirable as it can lead to reduced durability; for positive textured materials this can lead to increased noise generated by the traffic passing over it.

2.3.2.6 Noise

Tyre/road noise generation can be a problem in some situations. Surfacing layers with ‘negative’ texture such as Stone Mastic Asphalt (SMA) are quieter than conventional ‘positive textured’ chipped HRA by 2-3dBA or more. It should be noted that tyre/surface noise generation is more of a problem at high speeds. At low speeds engine and transmission noise are dominant. Porous asphalt - when newly laid - is currently the quietest material, with a reduction in noise (compared to new HRA) of approx. 4-5dBA, due to the voids absorbing sound. However, this advantage reduces as the pores fill with detritus, giving a relative reduction of approx. 3dBA, similar to SMA. Further information on surface noise is provided in DN-PAV-03023.

2.3.2.7 Impermeability

Sealing the surface of a pavement assists in prolonging its life. This is usually achieved in one of two ways; either the bond coat is applied heavy enough underneath the surface course to significantly reduce the permeability of the underlying layer or the material itself is dense enough to prevent or seriously impede water draining into the road structure. Bond coats used as sealers are considered ‘best practice’.

2.3.2.8 Resistance to Cracking

Cracking of surfacing materials is caused by a combination of factors including:

a) Thermal movement.

b) Repeated traffic loading and induced strain.

c) Embrittlement of binder due to ageing.

d) Shrinking of underlying soil.

Cracking has often been a problem associated with composite road construction, where thermal movement is concentrated above sporadically separated naturally forming cracks in the underlying cement bound material. Techniques introduced to induce cracks at closer spacings may help to alleviate this problem.

The fatigue characteristics of a mixture are largely governed by the volume and properties of the binder and the mixture’s ageing characteristics. Because binder ageing and the consequent embrittlement is a factor, fatigue cracking is likely to occur earlier in permeable materials than in impermeable ones since the binder can harden due to weathering throughout the depth of the permeable, more open materials. Cracking in less permeable surfacing materials tends to initiate in the first few millimetres of the surface where the binder is the most exposed and therefore the most embrittled, and propagate downwards. Cracks often start at the interface between the binder and aggregate, thus good adhesion between binder and aggregate is advantageous.

2.3.2.9 Ride Quality

This is generally improved for all materials laid with a paver incorporating a floating screed. This excludes microsurfacing, which is laid with a spreader box and continuous flow mixers, and surface dressing or other sprayed processes. Microsurfacing can improve the transverse shape of the pavement but has limited effect on the longitudinal profile.

2.4 Properties of Base, Binder and Regulating Courses

2.4.1 Introduction

Base and binder course mixtures form the main structure of flexible and composite pavements. A fully flexible pavement comprises bituminous mixtures in all layers and a composite pavement is made up of Hydraulically Bound Mixtures (HBM) in the base layers and bituminous mixtures in the binder and surface course layers. See DN-PAV-03021 for more information on the structural design of road pavements.

Requirements for Low Energy Bound Mixtures are specified in CC-SPW-00900 and advice on these mixtures is provided in Chapter 10.

Hydraulically Bound Mixtures incorporate cement or other hydraulic binders and are specified in the CC-SPW-00800.

Requirements for Low Energy Bound Mixtures are specified in CC-SPW-00900 and advice on these mixtures is provided in Chapter 10.

2.4.2 Characteristics of Base, Binder and Regulating Courses

These materials form the main structural layers of a pavement. Therefore, they need to have the following characteristics:

a) Good dynamic stiffness – to spread the load.

b) Resistance to permanent deformation – to prevent rutting under traffic.

c) Resistance to fatigue cracking – to avoid cracking and allowing water to enter the pavement.

d) Impermeability – preventing water entering the structure (except in pavements designed to be permeable, although these are not generally used on the National Road network).

In addition to the above direct performance characteristics, a suitable mixture also needs to be workable so that it can be placed and compacted easily. Also it should have inherent durability to avoid deterioration under the action of air, water and environmental stresses.

2.4.3 Long Life Pavements

Pavements are now constructed on the basis of long life performance of the structural layers, with long life being variously defined internationally as: ‘in excess of 40 years’, ‘indefinite’, or even ‘75 years’. The definition of long-life pavements (LLP) is functional, whereby the definition is based upon the expected performance characteristics rather than some specification of the design detail, and was adopted by ELLPAG (Ferne and Sinhal, 2004) as follows:

“*A Long-Life Pavement is a permanent structure that can be identified as one lacking any deterioration in the foundations and road base layers induced either by traffic loading, environmental conditions, material degradation or construction quality. Any distresses that might occur are confined to the surfacing layers only*.”

A paper prepared for the American Asphalt Pavement Alliance (Newcomb et al, 2000) lists the following advantages of long life pavements:

a) Low life-cycle cost by avoiding deep pavement repair or reconstruction.

b) Low user-delay costs since minor surface rehabilitation of asphalt pavements only requires short work windows that can avoid peak traffic hours.

c) Low environmental impact by reducing the amount of material resources over the pavement's life and recycling any materials removed from the pavement's surface.

2.4.4 Material Types

2.4.4.1 Asphalt Concrete

AC mixtures are continuously graded, dense materials manufactured in accordance with IS EN 13108-1 and CC-SPW-00900. Bases use 0/32mm nominal aggregate size whilst binder courses use a 0/20mm nominal aggregate size. A binder course layer is normally thinner than a base layer and higher binder content with finer aggregate grading can provide better compacted density and lower air voids. The smaller nominal size also helps to minimise segregation during placement of the layer.

2.4.4.2 Stone Mastic Asphalt

SMA mixtures are based on an interlocking coarse aggregate skeleton with a mastic of fine aggregate, filler and bitumen manufactured in accordance with IS EN 13108-5 and CC-SPW-00900. They can be used as binder course and regulating course. As SMA products are binder rich they usually need the addition of fibres and/or the use of a polymer modified binder to prevent binder drainage.

2.4.5 Constituents of Bases and Binder Courses

2.4.5.1 General

The major constituents of base and binder courses are coarse and fine aggregates, filler and bituminous binder. Fully designed mixtures are required to meet the requirements of CC-SPW-00900.

2.4.5.2 Coarse Aggregate

For heavily trafficked roads the coarse aggregate is normally crushed rock, which usually comes from established quarries with a proven track record. Gravel aggregates can be used subject to being 100% crushed and can perform well provided the mixture is carefully designed. The adhesion of binder to some types of rock and many gravels can give rise for concern, although this can be addressed using chemical additives and is further discussed under durability. Coarse aggregates should conform to the relevant Clauses in IS EN 13043. The PSV of aggregates used in bases and binder courses is rarely a consideration (unless used as a temporary running surface for an extended period) and therefore a wide range of rock types, which occur in Ireland can be used. Limestone is often the preferred material as it is relatively easy to quarry and has good affinity with binder.

2.4.5.3 Fine Aggregates

AC materials normally use crushed rock fine aggregate of the same type as the coarse aggregate. However natural sands or blends of crushed rock and natural sands can be used.

SMA binder courses, permit crushed rock sands or a blend of crushed rock and natural sand with a maximum of 50% natural sand.

When washed sands are used, particularly if they have high filler content or are towards the fine limit of the grading, extra care will be needed to ensure that the aggregate is fully dry before using. Failure to do this will increase the probability of binder stripping and will lead to poor performance.

2.4.5.4 Fillers

Filler for AC is usually filler from the parent rock, but limestone filler may be used. When the aggregate is gravel, at least 2% by mass of the mixture should be hydrated lime or Portland cement; these are added to improve adhesion, which would otherwise be poor.

The use of 2% hydrated lime or cement improves the adhesion of binder to crushed rock and is particularly valuable where the water sensitivity test or historical data have shown poor compatibility between the binder and the aggregate.

2.4.5.5 Binders

The conventional binders used in bases and binder courses are paving grade bitumens to IS EN 12591. These range from 40/60 at the hardest end of the range up to 160/220 at the softest end.

The choice of binder for SMA is limited to 40/60 or 70/100 paving grade bitumen, but polymer modified binder is permitted with a grade of 65/105-60. The polymer should be pre-blended. Adding the polymer at the mixer is not permitted, because it introduces significant control problems particularly that of ensuring that the polymer is evenly distributed throughout the binder.

2.4.5.6 Minor Constituents

Minor constituents usually contribute less than 0.5%, sometimes much less, to the total mixture. The most common are fibres and adhesion agents. Fibres may be natural or man-made, and are normally used to enable a thicker binder film (higher binder content) to be achieved without risking binder draining from the aggregate. They are most frequently used in SMA binder courses.

Adhesion agents are added to a mixture when it is known that there are problems with binder adhering to the aggregate. They are proprietary products and some have a relatively short life at high temperatures. They are usually effective, but they are only used to improve initial adhesion. Subsequent attacks on adhesion by the environment (such as water, road salt, climate, traffic stresses and ageing) may not be resisted by adhesion agents at the normal level of addition, although the improved initial adhesion will reduce the severity of any debonding.

2.4.5.7 Reclaimed Asphalt Materials

Reclaimed Asphalt (RA) may be used as a constituent in the production of bituminous base, binder course, and regulating course mixtures. The primary requirement is for consistency of the feedstock. This is usually achieved by carefully controlling and segregating source materials of different constituent type and mechanical properties. It is classified in accordance with IS EN 13108-8 and specified in accordance with CC-SPW-00900. The mixed material must also comply with the requirements of CC-SPW-00900.

When the amount of RA in a mixture comprises 10% or less by mass, the design parameters and frequency of test are not as onerous compared with mixtures containing more than 10%. This relates to the potential risk that the RA may have on the long term performance of the mixture. Although a high number of projects internationally have been constructed with higher percentages of RA, there is limited research and evidence of the long term performance of the material and where information is of rutting and crack resistance, but not specifically resistance against fatigue.

The long-term performance of an asphalt pavement can be significantly reduced by the presence of water in the pavement structure and the detrimental effect that water has on the mechanical properties of the mixture. Moisture-induced damage is an extremely complicated mode of distress that leads to the loss of stiffness and structural strength of the asphalt and eventually to the premature failure of the pavement structure. A dislodging process of the aggregates occurs, which is known as ravelling or stripping of the asphalt mixture. The loss of the aggregates from the mixture may exhibit either a cohesive (i.e., within the binder which consists of bitumen and filler) or an adhesive (i.e., within the binder-aggregate bond) failure pattern. Even though not necessarily initiated by the presence of water, most pavement distress mechanisms (cracking, permanent deformation, raveling, etc.) will be increased in extent and severity with the presence of water or other forms of moisture. TII has invested in research projects to further understand and evaluate this aspect of durability. The results of the research will enable a higher confidence level in the durability of higher RA percentage in the future.

The penetration value of the binder recovered from RA should not be less than 15. One of the factors affecting this limit is that the mixing temperature would need to be too high to ensure that the old binder is fully incorporated into the new and therefore contributes to the total binder content (see CC-SPW-00900). If this does not happen, the mixed material will have a very low 'effective binder content' and this will affect the durability of the product; possibly to the extent that the reduced life would negate any carbon reduction from the use of RA in the first place. If there is any doubt, further investigation should take place to demonstrate the efficacy of the process.

2.4.6 Factors affecting Material Durability

2.4.6.1 General

Primary factors which affect the durability of the base and binder courses are the binder content within the mix, the durability of the binder and the binder/aggregate affinity. Characteristics of binders are discussed in Chapter 2.

There are a number of factors in the design and construction of bituminous bases and binder courses that affect the durability of the material in the pavement; these include:

a) Aggregate durability.
b) Filler
c) Compaction.
d) Fuel resistance
e) Healing.

These material characteristics are discussed in the following Sections.

2.4.6.2 Aggregate Durability

Most aggregates used in bituminous mixtures have a history of use and their durability is judged on practical performance over many years. However, when new sources of aggregate are introduced, which do not have an established track record, they will require their durability to be assessed. There are also some aggregates which have had a variable performance in the past. The introduction of IS EN 13043 has brought together a range of requirements including those that check for durability.

Problems associated with inadequate durability of aggregates are minimised when appropriate care has been taken to use aggregates of known durability and the products have been made and laid in accordance with the requirements of CC-SPW-00900.

2.4.6.3 Filler

Fillers can have a significant effect on the durability of a mixture. Reclaimed filler from the production process is composed of material derived from whatever aggregate is being processed and may therefore be comprised of limestone, hardstone, gravel or sand particles and in varying proportions. The effect that these fillers may have on the final bituminous mixture is variable. CC-SPW-00900 restricts the use of these fillers in the surface courses but not the base and binder layers. However, the water sensitivity test may help to determine the effect that reclaimed filler can have on the final mixture.

2.4.6.4 Compaction

With the possible exception of binder content, good compaction is probably the most important factor affecting durability. Good compaction can be achieved by using a sound mixture design and good quality workmanship to ensure that the air voids requirements of the CC-SPW-00900 are fully complied with.

2.4.6.5 Fuel Resistance

Fuel resistance is not normally a requirement for bituminous materials used on carriageways; however, there may be some situations where defects associated with bituminous materials in contact with fuel may be greater, such as in lay-bys. Diesel fuel and hydraulic fluid have the capability to cause long term damage to bituminous materials, however petrol spillage is not usually a significant problem as it evaporates quite quickly before it can have much effect on the bitumen.

The best protection by far is prevention by adequate care, particularly by avoiding spillage of diesel oil or hydraulic fluid by construction plant. However, if spillage does occur then the affected material must be removed and replaced with sound material conforming to CC-SPW-00900. If this is not done, the pavement will fail prematurely in the affected areas. Well compacted materials are less prone to damage than poorly compacted ones because the penetration of the offending fluids is reduced.

2.4.6.6 Healing

A feature of bituminous materials that can improve their durability is that in warm weather many small cracks (micro-cracks) can heal up as a result of viscous flow and diffusion. Although healing is known to occur, it is difficult to quantify the effect with any degree of certainty and research considering dissipated energy and loading frequency is necessary, especially for hard paving grades.

3. Bituminous Pavement Options

3.1 Introduction

The following sections provide guidance on choosing surfacing courses, binder and regulating courses and base materials.

3.2 Choosing a Surfacing Material

The choice of surfacing products plays a vital role in providing roads that meet the needs of the user, are safe and give value for money. For many years HRA with chippings rolled into the surface was the most widely used surfacing on National Roads, including motorways, for both new construction and life cycle maintenance. Surface dressing was also widely used on National Secondary roads. Recent years have seen the development of new materials and techniques 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.

Apart from the suitability of surfacing materials in terms of safety and robustness, the permitted pavement surfacing options for use on National Roads, have been determined by TII are indicated in DN-PAV-03023 Table 2.1.

The decision on which of the permitted options are used within a Scheme should be made on a site-specific basis, taking into account the existing surfacing type, adjoining works and the scale of the works. It is very important to maintain local consistency in surface type and from the driver's perspective the changes should be minimised. Different types of surfacing can also have different winter maintenance treatments so it is preferred to have consistency of surfacing types along salting routes whenever possible.

Where noise levels are high due to the volume of high-speed traffic, surfacing materials are available that can significantly reduce tyre/road generated noise emission compared to HRA including SMA and Porous Asphalt. Conversely, in locations where speeds are limited and tyre/road generated noise low, or where traffic volume (and therefore the overall noise level) is not significant, then the noise reducing benefits of these surfacings will be limited and, therefore, the full range of suitable surfacings should be considered.

Where Porous Asphalt is proposed for use on high speed roads, the approval of TII shall be sought and a Departure from Standards agreed prior to incorporation in the permanent works.

The surfacing options permitted shall be those shown in DN-PAV-03023 Table 2.1. Where an option is permitted with “Departure Required”, a Departure from Standard will be required from TII.

Solely for the purpose of this Standard, high-speed roads are defined as those with a posted speed limit above 60 km/h.

The various pavement construction types are defined in DN-PAV-03021.

TII should be contacted for advice on suitable materials for use on concrete pavements.

Retexturing can provide improvements to the existing surface. Further information on retexturing of bituminous surfacing is provided in Chapter 12.

3.3 Choosing a Binder or Regulating Course Material

There are two basic types of material to choose from:

a) AC base and binder courses.

b) SMA binder course.

For most purposes the binder course used will be dense AC in accordance with IS EN 13108-1. Where a base layer has been used, the binder course should match it. For example, a base using a 40/60 paving grade bitumen should have a binder course of matching type and bitumen grade.

The thickness of the regulating course layer should ideally be in the range of 2.5 to 3.5 times the nominal aggregate size. This range ensures that the thickness of the layer is neither too thin (so that a competent layer which will not become overstressed will be provided) nor too thick (which can result in inadequate compaction, surface undulations during laying and can cause dragging of the finished surface leaving an inconsistent finish with respect to density and homogeneity).

SMA binder course is typically used in maintenance situations where a new inlaid surface course is thinner than the surface course that has been planed out. Old surface course on major routes would typically be 40 to 50mm thick chipped HRA. In some cases, it may be necessary to cold mill to a depth of 55mm to ensure removal of all the surface course, before being replaced by a SMA surface course. In this situation, there could be a deficiency of between 15 to 25mm, which requires a material with appropriate aggregate size and good resistance to permanent deformation such as SMA binder course to be used as a regulating course. To ensure the target density is achieved, compaction should be very carefully monitored, especially when laying these thin layers in adverse weather conditions.

CC-SPW-00900 Table 16 provides requirements on the thickness of regulating material. The absolute minimum depth of regulating material is 10mm utilising the SMA 6 binder mixture. For depths lower than this it would be necessary to either cold mill the existing material to achieve the required profile or to provide a deeper depth where needed on the subsequent layer. As consistency is an important perspective in achieving quality workmanship, the choice of which of the two options is better should be taken on a scheme by scheme basis.

The use of a polymer modified bituminous emulsion bond coat is even more important when relatively thin layers of regulating course are being used.

3.4 Choosing a Base Material

The most commonly used base material for all roads is dense AC in accordance with IS EN 13108-1. The only choices to be made for dense AC base are:

a) What grade of binder is to be used?

b) What quantity of filler is to be used – in terms of specifying a dense or Heavy Duty Macadam (HDM) product?

c) Minimum binder content to be used?

There may be advantages in using thicker layers with a softer binder if it is necessary to lay in adverse conditions such as winter nights. It should be noted that new works could be constrained to have thinner layers e.g., a new roundabout on an existing road.

Another option that has been used and could be considered, particularly where the unbound layers are likely to be or remain wet, is to use a mixture with a higher than normal binder content; AC mixtures with an extra 0.5% would help to prevent stripping of binder from the bottom of the asphalt layers. This strategy also helps compaction in the bottom layer of asphalt, which is often more difficult than for subsequent layers as the reaction from the underlying unbound material can reduce the compactive effort of rollers. Resistance to rutting is not a problem at this level, but the likely higher resistance to fatigue could be advantageous.

4. Hot Rolled Asphalt

4.1 Introduction

Hot Rolled Asphalt (HRA) is a dense, gap graded bituminous mixture in which the mortar of fine aggregate, filler and high viscosity binder are major contributors to the performance of the laid material. Coated chippings (nominally single size aggregate particles with a high resistance to polishing, which are lightly coated with high viscosity binder) are rolled into the surface to improve skid resistance and drainage.

The main strength of a HRA mixture comes from the stiffness of the sand/filler/binder mortar. A major factor in the performance of the mortar is the binder, normally grade 40/60 bitumen or polymer modified binder with approval of TII. Filler stiffens the bitumen which binds all the aggregates together. Some filler is contained in the fine and coarse aggregates in the mixture, but most is added to the mix. The design process optimises the binder content for the chosen constituents used.

The addition of coated chippings to the HRA prior to full compaction enables the skid resistance requirements to be satisfied. Good workmanship is required on site to ensure the correct embedment of chippings. The chippings should be consistently and evenly spread across the mat with minimum of 60% - 70% of the chippings in contact with adjacent chippings (“shoulder to shoulder”). Ideally the mosaic should be 100% as gaps may permit tyre contact with the mortar rather than the chipping. To ensure contact with vehicle tyres, the chippings must have a positive texture and be laid to be proud of the asphalt mat.

4.2 Design

The requirements for the mix design and designation for HRA mixtures are set out in DN-PAV-03074.

4.3 Specification

HRA mixtures shall be manufactured, delivered and laid in accordance with CC-SPW-00900.

4.4 Properties

In addition to the properties of the sand, binder properties are crucial to the production of a high rutting resistant material. The HRA must have sufficient workability for placing, laying, compaction and pre-coated chipping retention. It must also have durability, adequate resistance to rutting, stiffness, resistance to water ingress and resistance to binder degradation.

The CC-SPW-00900 requirement for resistance to permanent deformation may result in the increased use of polymer modified binders. Such binders have been used to help reduce deformation or wheel tracking rates and mixtures have been found to be reasonably easy to lay and compact. However, their benefits in terms of reduced temperature susceptibility and elasticity have yet to be fully established, especially in the long term.

In terms of performance criteria, the resistance to permanent deformation can be measured from core samples taken from the road.

In order to ensure long term durability, resistance to permanent deformation must not be the only consideration; ageing (which is also important and is related to the voids in the mixture), binder characteristics and binder content can be analysed from samples taken.

Whilst cement is a permitted filler, most HRA is made with limestone filler. Reclaimed filler is not permitted in HRA surface courses as it is derived from the filler extracted from the constituents used in the manufacture of the bituminous material; the provenance of the filler is therefore unknown as the constituents could be limestone, hardstone and / or sand or varying proportions.

The coarse aggregate may be crushed rock or crushed gravel. In chipped HRA surface courses, which are laid to nominal thicknesses of 40 mm or 45 mm, the nominal single size coarse aggregate is 14 mm. The coarse aggregate particles increase the volume of the asphalt and reduce its cost but, since they do not form a skeletal structure, they do not add very greatly to its deformation resistance.

The combination of properties needed may require a detailed analysis of the effects of different sands on the performance of the mixture and by blending sands. As an example, the addition of a proportion of crushed rock can improve the resistance to rutting and, in some cases, improve the workability.

The rate of rutting of a particular surface course depends on the temperature of the surface as well as the traffic loading/speed and material properties. The stability test (commonly known as the Marshall test) was introduced in 1976 to assess all sands, and criteria were introduced for various traffic categories on the basis of commercial vehicle traffic. Vehicle tyre pressures have increased over recent years which concentrate rutting forces into a narrower track. A more stringent requirement than the Marshall Stability test has therefore become necessary for the design of surface courses. For this reason, the wheel tracking test has been introduced as a requirement for HRA in particular.

The need to retain chippings should not be forgotten, the less workable the mix and the more adverse the weather conditions during laying, the more likely the possibility of significant chipping loss. Rapid cooling of the top surface of the asphalt, forming a surface skin, can prevent adequate chipping penetration. This is particularly relevant when laying polymer modified HRA in cold or windy conditions.

4.5 Performance and Durability

HRA surface course has generally performed well, with good durability and levels of safety. According to a European study (EAPA, 2007), well designed HRA may offer between 17 and 25 years of service life on heavily trafficked European roads. As the constituents are principally natural materials and the effects particularly of environment (refer to section 2.3.2.2) are unpredictable the durability stated is only a guide. A reasonable tolerance of weather conditions at the time of laying permits the placing of the material in winter and at night. The design of the mortar is critical for adequate rut resistance. Experience has shown that the sand fraction is important, with rounded particles performing poorly compared to angular sand.

HRA has sometimes suffered from poor resistance to permanent deformation in wheel tracks (otherwise known as wheel tracking or wheel track rutting).

This is particularly evident on roads with high concentrations of commercial vehicles, slow moving heavy vehicles on hills and can also be caused by early heavy trafficking after laying, before the material has assumed its full strength. Current specification requires a designed performance that demonstrates a high level of resistance to permanent deformation.

Over embedment of the chippings can significantly reduce the durability of the HRA mix. In some cases, this may not be detected by texture depth testing if there are clusters of chippings rather than a “shoulder to shoulder” spread.

The effect is of a texture below the surface and not above it as designed and this may lead to tyre contact with the mortar in a relatively short time frame. To compensate for this on roundabouts, where it is recognised that some chipping loss is more likely to occur, the current specification requires a higher PSV than heretofore in the coarse aggregate content of the mortar.

5. Stone Mastic Asphalt

5.1 Introduction

Stone Mastic Asphalt (SMA) consists of discrete and almost single sized aggregate particles (typically around 70% by mass) forming a skeletal structure bonded together by mastic. This mixture is of often used as a surface layer in cases where high stability is needed.

The mastic consists of a blend of crushed rock, sand, added filler (usually limestone) and a polymer modified binder, or for lower volume roads a paving grade binder, plus an additive or modifier to prevent binder drainage whilst the material is hot. The most common additive is cellulose fibres, but mineral fibres have also been used.

At the bottom, and in the bulk of the layer, the voids in the coarse aggregate are almost entirely filled by the mastic, while at the surface the voids are only partially filled resulting in an open ‘negative’ surface texture. Provided texture is maintained, this provides good skidding resistance at all speeds and facilitates the drainage of surface water. A careful choice of aggregate size, shape and grading is necessary to produce a surface that will meet the requirements for high speed roads.

5.2 Design

The requirements for the mix design and designation for SMA mixtures are set out in DN-PAV-03074.

5.3 Specification

SMA mixtures shall be manufactured, delivered and laid in accordance with CC-SPW-00900.

5.4 Properties

A correctly designed SMA mixture should exhibit the following properties:

a) Strong aggregate skeleton, to promote high resistance to deformation.
b) Binder rich, to promote durability and resistance to cracking.
c) Much coarser surface texture than conventional dense graded asphalt, which provides the enhanced skid resistance and good light reflectivity.

Noise measurements in other countries have shown that SMA surfacing is significantly quieter than AC.

SMA is also specified for use as a rut resistant binder course and as a regulating layer.

5.5 Performance and Durability

Research worldwide has demonstrated that SMA generally performs well. The main problems with SMA have been associated with fretting, ‘fatting up’ and damage due to the substantial use of de-icing chemicals, which are typically used in Northern Europe for winter maintenance. For example, in Finland, de-icing chemicals are suspected of being the cause for the appearance of some soft binder-rich, sticky surface spots with low friction. According to a European study (EAPA, 2007), well designed SMA may offer between 14 and 25 years of service life on heavily trafficked European roads.

Again, as the constituents are principally natural materials and the effects particularly of environment (refer to section 2.3.2.2) are unpredictable the durability stated is only a guide.

SMA has proved to be durable and resistant to age hardening as a consequence of its low void content and thick binder film. As a result, it is resistant to premature cracking, ravelling and moisture damage. Other advantages claimed for the material are its ability to shape an uneven or rutted surface as the majority of the compaction is carried out by the paver and there is little further compression under rolling. It is necessary to limit the void content to ensure adequate durability. However, if the void content is too low, deformation usually occurs resulting in a loss of surface texture and rutting. The specified range of air voids content is between 2% and 5% for surface courses.

It has been observed that there is potentially a greater risk associated with open texture when larger aggregate sizes are used, leading to increased permeability of the SMA surface course. This may trigger fretting and other moisture induced damage within the SMA layer and/or the layer underneath. Alternatively, the use of high binder content, if not balanced with suitable aggregate grading and/or other additives, may lead to ‘fatting up’ problems. It is for this reason that CC-SPW-00900 requires the mix to be designed so as to have both a minimum and a maximum texture depth.

Increasing the binder content improves durability. It achieves this by increasing the film thickness around the aggregate, which could in turn give rises to concern of potentially lower early life skid resistance of the SMA surface course in the period that the binder is worn off the aggregate. TII undertook an extensive research programme with TRL in the UK to assess the optimal methodology to address this concern. The result is the requirement in the current mixture specification, for fine aggregates within the mix to meet a minimum PSV value. It was observed that the fine aggregate (0/2 and 0/4 grading) effectively formed a “mortar” with the binder and has a beneficial influence on the early life skidding resistance. There are also two surface course mixes with paving grade binder and these are specifically for use on low volume roads. Further information is provided in DN-PAV-03023 and CC-SPW-00900.

6. Porous Asphalt

6.1 Introduction

Porous Asphalt (PA), consists primarily of gap-graded aggregates held together by binder to form a matrix with interconnecting voids through which water and air can pass in order to provide the compacted mixture with drain and noise reducing characteristics.

It acts as a reservoir and, provided that the crossfall or longitudinal fall is sufficient, acts as a lateral drain throughout the time it is wet. It is important that PA is laid over an impermeable layer that protects the lower layers of the pavement from ingress of water.

Unfortunately, the interconnected voids allow excellent access to air; so ageing and embrittlement is potentially exacerbated, therefore a polymer modified binder is necessary.

Not all voids within the mix are interconnected and this gives rise to some storage of water within the surface course. Capillary action by traffic will usually bring this water to the surface and dissipate it to the carriageway edge. In cold conditions this may come to the surface and freeze in what has been described as “ice rails”. To counteract this the use of brine or suitably graded salt as a de-icing procedure is necessary.

The bond coat used beneath PA is specified to further waterproof the underlying pavement layers and to maintain good adhesion; the rate of spread should be increased to a level that will ensure protection against permeability of the underlying layer, unless the pavement structure is specifically designed to be pervious and self-draining.

6.2 Design

The requirements for the mix design and designation for PA mixtures are set out in DN-PAV-03074.

6.3 Specification

PA mixtures shall be manufactured, delivered and laid in accordance with CC-SPW-00900.

6.4 Properties

Rain water on road surfaces can be hazardous to motorists; surface skidding resistance is reduced and spray generated by moving vehicles, particularly those travelling at high speeds, decreases driver visibility. PA reduces these problems due to its open texture which acts as a drainage layer, removing surface water during rainfall and reducing traffic generated spray. CC-SPW-00900 has a relative hydraulic conductivity test to ensure sufficient interconnected voids are present. Unfortunately evidence from the Netherlands indicates that PA is no safer than conventional surfacing. The reason for this may well be that drivers who are normally inhibited from driving at higher speeds in wet weather, tend to drive faster when spray is suppressed and in-car noise reduced.

The level of noise emitted at the tyre/road interface, on a PA surface, is lower than for most other surface courses offering comparable skid resistance. On high-speed roads surfaced with PA, the average reduction in dry road surface noise levels, compared with conventional hot rolled asphalt is approximately 4dBA for ‘light’ and 3dBA for ‘heavy’ vehicles. The reduction is more pronounced in wet weather.

PA reduces traffic noise by acoustic absorption and in addition, during wet weather, the rapid drainage properties of the material reduce the incidence of noise caused by the generation of spray.

PA reduces the glare reflected from wet surfaces due to sunshine during the day, or vehicle headlights during the night.

PA gives most benefit on high-speed roads, particularly those with concentrations of commercial vehicles.

Spray generation and dispersion is related to tyre width and tread, vehicle profile, vehicle speed and rainfall intensity, as well as road surface characteristics.

The most efficient method of draining water from PA is an open, free face at the edge of the carriageway. However, a 50 mm vertical step may have undesirable safety implications for some road users. Guidance on the design of the Edge of Pavement Details for Porous Asphalt Surface Courses is provided in UK DMRB HA 79/97 and is not formally implemented by TII but should be considered as “background reading” indicating good practice.

PA performs best on roads such as motorways and rural dual carriageways. These tend to have:

a) High-speed traffic.

b) Good vertical and horizontal alignment.

c) An effective drainage system.

d) Few, if any, junctions.

PA should not be used in the following situations:

a) On areas where the pavement strength is sub-standard.

b) On areas where there is already ponding in ruts and depressions.

c) On areas where there is considerable acceleration, braking, turning and parking.

d) On tight radius curves, and loops with radii less than 75m, or when gradients exceed 10%, without advice from TII.

e) On areas where excessive deposits of detritus or oil and fuel may be experienced; such as parking areas, exits from farms and quarries and other industrial sites.

f) On areas where the use of tracked vehicles, construction plant, farm equipment or similar industrial vehicles is expected.

g) On areas where the crossfall is insufficient to remove water to the road edge, such that flooding may occur in the PA.

h) At locations where free drainage cannot be accommodated along the low edge of the surfacing e.g., abutting other types of construction such as a concrete carriageway.

i) Generally, on lengths of carriageway of less than 100m, because of spray carry-over from adjacent surfacings, unless special conditions prevail.

j) On steel decked bridges except where expressly permitted by TII

k) In urban environments and in speed restricted areas where tyre/road surface noise generation is low, unless approved by TII.

l) Where frequent excavations by statutory undertakers may occur.

m) On carriageways having a 50 kph speed limit – as there is no beneficial reduction in spray or noise levels achieved at low speeds.

There is a carry-over of rainwater for approx. 100m by vehicles moving from impervious surfaces onto PA. To ensure satisfactory spray suppression for a particular length of road, the length of road surfaced with PA should extend for a minimum 100m upstream of the section where treatment is required.

On multi-lane carriageways, where an impermeable surface is laid downstream of a PA surface, the lane ends of the PA should be staggered across the carriageway, in the direction of the drainage path. This will avoid excess water welling up over the transverse joint.

On slip roads, PA should be continued until a convenient stop-point is identified, such as a straight alignment of constant gradient but not less than 50m before a give-way or stop line. It should always be stopped before areas of high stress, such as intersections with roundabouts and other junctions, when high skid-resistant materials may be required. PA can be used on merging and diverging lanes, where it should extend the full width of the carriageway at the taper and should preferably also be used on the nose area and the slip road beyond.

6.5 Performance and Durability

The durability of PA is dependent on the binder content, the quality of the laid material, the soundness of the base on which it is laid, the site characteristics, design layout, drainage and traffic flow. When water is retained within PA, because of poor drainage, its life will usually be reduced. Frequent braking and turning movements by heavy traffic may also cause surface fretting and early failure.

PA performs best on high speed roads having good vertical and horizontal alignment, an effective drainage system and few, if any, junctions. These tend to be the case for motorways and rural dual carriageways.

Some reduction in void content and a closing up of surface voids occurs during service, due to the accumulation of detritus and surface compaction by traffic. This causes a reduction in relative hydraulic conductivity and increased spray levels. Traffic noise levels also increase. However even when the voids are closed up, PA still provides a good reduction in noise levels and spray generation similar to SMA, when compared to HRA surfaces, due to cross-surface drainage within the surface texture and sound absorbency.

There is currently no reliable and effective method of removing detritus from the voids of PA. The wheel track areas seem to remain relatively clear, possibly due to the suction effect of passing tyres. The problem of detritus clogging the voids of PA is pronounced when it is used on the hard shoulder or hard strip. This is considered to be due to detritus migrating within the PA towards the lower edge of the pavement.

According to a European study (EAPA, 2007), well designed PA may offer between 8 and 14 years of service life. The surface appearance of PA surface course changes with time as the binder coating becomes aged or removed from the surface. Once again, as the constituents are principally natural materials and the effects particularly of environment (refer to section 2.3.2.2) are unpredictable the durability stated is only a guide.

7. Microsurfacing

7.1 Introduction

Microsurfacing is part of the Slurry Sealing family of surfacing materials as defined by the Comité Européen de Normalisation (CEN). Microsurfacing is the only slurry sealing material approved for use in CC-SPW-00900 and its main distinguishing feature is the adoption of a larger aggregate sizes compared with the other slurry sealing materials.

In accordance with DN-PAV-03023 Table 2.1, microsurfacing is only approved for posted speed limits of below 60kph and a departure is required for their use on the National Road network. As a result, microsurfacing will generally only be used in urban areas and, compared with surface dressing, may be used in limited cases where there is a need to seal underlying cracks.

Microsurfacing has a low carbon footprint and is an economic method of preserving the road pavement. It can also restore skid resistance however because of its relatively fine textured mosaic it has a lower life expectancy than other surfacing materials. It is a cold-laid, sustainable product which optimises the use of high performance aggregates.

Microsurfacing mixtures comprise aggregates, fillers (cement) and bitumen emulsions or polymer modified bituminous emulsions, which may also contain fibre additives. Microsurfacing ranges in thickness from approx. 10mm to 20mm.

Microsurfacing is distinguished from slurry surfacing by aggregate size. Slurry surfacing includes 0/2mm and 0/4mm aggregates, whereas microsurfacing uses coarser aggregates, generally 0/6mm and 0/8mm, and is normally laid in two layers: a base layer and a surface layer.

Where permitted in accordance with DN-PAV-03023, microsurfacings require appropriate levels of skid resistance and texture retention. They permit only limited surface regulation when laid in one pass. If greater surface regulation is necessary, an initial pass may be made to fill in surface irregularities, such as minor rutting, followed by a second pass to provide the complete overlay.

Improvements in rutting and friction characteristics are the most frequently mentioned benefits gained from microsurfacing. It has also been shown to perform efficiently at reducing bleeding. Also, surface dressings, in addition to their performance limitations, are often associated with windshield breakage and increased noise, while microsurfacing does not suffer from either of these limitations to the same degree.

The addition of fibres within the microsurfacing processes can be utilised to reduce reflective cracking and enable the use of coarser aggregates which improves texture depth.

7.2 Design

The requirements for microsurfacing design are set out in DN-PAV-03074.

7.3 Specification

Microsurfacing shall be manufactured, delivered and laid in accordance with CC-SPW-00900.

7.4 Properties

There are currently no microsurfacings that can maintain adequate surface texture for the full expected life of the product. Reasonable values for microtexture (i.e., low speed skid resistance) and abrasion resistance may be obtained by selection of a suitable aggregate type with a minimum Polished Stone Value (PSV) and maximum aggregate abrasion value (AAV) in accordance with DN-PAV-03023. Aggregates with a high PSV are required for stressed sites such as braking areas, hills or bends. Aggregates with a low AAV are necessary for heavily trafficked sites to reduce the rate of wear.

7.4.1 Appearance

Microsurfacing may be used on road surfaces that have undergone a number of reinstatements, or significant patching, in order to provide a more uniform overall appearance. They can be used on surfaces that are fretting, and on those showing early signs of ravelling, to halt further deterioration. Further guidance on suitability of site for microsurfacing is provided in DN-PAV-03074. Coloured aggregates or mixtures may be used for delineating hard shoulders and central reserves, or for traffic calming measures where traffic levels are appropriate.

7.4.2 Conservation

Cold milling before treatment is not necessary when the profile is acceptable, and ironwork may not need to be raised for microsurfacing works. Material usage is low, components are mixed cold using damp aggregates and no energy is expended on drying and heating the constituents.

7.4.3 Environment

The use of cold laid maintenance products using bituminous emulsion binders are encouraged because they are environmentally friendly; the emissions are almost entirely water vapour and the installation has a low carbon footprint. This also results in minimal degradation of the polymer binder during storage and installation. Waste materials (bitumen and aggregate) are not classified as hazardous.

7.4.4 Profile

As the product is spread using a fixed screed mounted on skis, microsurfacing can improve the transverse shape of the pavement but has no significant effect upon the longitudinal profile.

7.4.5 Ride quality

Microsurfacing with a base layer may improve ride quality, particularly if the problem is caused by undulations of very short wavelength. Undulations with a wavelength greater than approx. 1m may be slightly improved.

7.4.6 Noise

The macrotexture of microsurfacing is generally low and the coarse aggregate provides a slight positive texture, but the peaks are less regular than is the case with surface dressing and this generates less tyre/road interface noise. The tyre/road noise generation reduces over time due to wearing down of the pavement.

7.4.7 Permeability

Although microsurfacing can arrest surface deterioration, most products are permeable to a greater or lesser extent. They should not be assumed to be entirely waterproof. Where a bond coat has been used, or the treatment is over a newly laid surface, a significant reduction in permeability may be expected.

7.4.8 Preservation

Microsurfacing can be used on surfaces that are fretting, and on those showing early signs of ravelling, to halt further deterioration.

7.4.9 Adhesion

The adhesion of a surface course to the underlying pavement structure is essential, particularly so with microsurfacing. It is not thick enough to carry traffic induced stresses without excellent adhesion. Bond is even more important where there is a possibility of high braking and lateral stresses. Structural strength is only fully developed when all the layers in the pavement are well bonded, effectively forming a single layer.

7.5 Performance and Durability

Microsurfacing with a bond coat seals the underlying road pavement against the ingress of water and air, which cause deterioration of the structural courses of the road. This is preventative maintenance, which directly influences the durability and therefore the life of the road. In order to maximise this protection, microsurfacing should be applied as soon as minor crazing or fretting is first detected, which is well before the critical condition (major deterioration) is reached when often the only solution is removal of the surface course and even lower layers.

8. Surface Dressing

8.1 Introduction

Surface Dressing is the application of a bituminous binder and nominal single size aggregate chippings to the surface of a road, in one or more layers. The procedure is one of the most common of all surface treatments used and is a principal method of routine maintenance of road surfaces in Ireland. It has become increasingly important since the introduction of standards for skidding resistance on National Roads as set out in AM-PAV-06045. It offers an economic surface treatment as it requires minimal quantity of high PSV aggregate.

Surface Dressing has a low carbon footprint and is a low cost method of restoring skid resistance, sealing and preserving the road pavement. The concept is straightforward; in its simplest form a thin layer of bituminous binder (generally a cationic polymer modified bituminous emulsion) is applied to the road surface and very clean stone chippings, nominally single-sized, are spread and rolled into it. For higher stressed sites a second application process consisting of smaller aggregate is concurrently applied.

Surface Dressing performs the following two functions which relate directly to essential requirements of the Construction Products Regulation:

a) **Safety – Skid Resistance**: Surface dressing increases the macrotexture and improves the microtexture of the road surface. These properties significantly increase the skidding resistance of the road surface and enhance road safety.

b) **Durability – Preventative maintenance**: Surface dressing seals and binds road surfaces, protecting the underlying layers from the ingress of water and air. This mitigates deterioration of the structural courses of the pavement, thus increasing the durability of the road. It is preventative maintenance, which directly influences the durability and therefore the life of the road. For this reason, surface dressings are sometimes referred to as ‘preservatives’ or ‘sealers’. In order to maximise this protection, surface dressing should be applied as soon as minor crazing or fretting is first detected and before major deterioration of the pavement occurs as this would require much more expensive full reconstruction of the pavement to repair.

While surface dressing does not provide increased strength to the structure of a pavement, it may form a part of strengthening techniques, for example, overlays, partial/full reconstruction, etc.

If the existing road surface has a poor profile or is deformed in the wheel tracks (a rut depth greater than 10 mm) then pre-treatment by cold milling or surfacing may be required. Thin asphalt surfacing overlays in these circumstances may have greater economy as they have some ability to improve profile. However, in some locations, particularly those where vehicles undertake sudden or sharp turning movements, some restrictions to the type of dressing will be required and in very severe situations other treatments may be more economical. This is due to the relatively poor ability of the process to resist tangential forces.

In a new road, the required surface texture is designed by specifying requirements for both aggregate properties and texture depth. However, during its service life, the surface becomes polished under the action of traffic and the skid resistance will reduce eventually falling below the minimum specified value. A benefit of surface dressing is that the process restores skid resistance to a surface that has become smooth under traffic.

8.2 Surface Dressing Techniques

There are a number of different systems of surface dressing available. The durability and suitability of surface dressing in certain site conditions may be greatly enhanced by using types of surface dressing other than single surface dressings, and/or the use of modified binder. The most common types of surface dressing are discussed in the following sections.

Surface dressing relies on the embedment of the chippings by traffic after laying of the material. However, there are circumstances where it is not possible to provide controlled low speed trafficking which is normally used to settle a dressing down prior to sweeping and opening to unrestricted traffic. Lane switching may be permitted to enable sweeping after a period of unrestricted trafficking. In such circumstances it is vital to produce a very stable dressing that can be swept prior to opening to reduce the risk to traffic.

8.2.1 Single Surface Dressing (single binder single chipping application)

The basic surface dressing technique using a single application of binder followed by a single application of chippings, usually 6 or 10 mm, is satisfactory for most lightly trafficked roads (see Figure 8.1). Use of a modified binder in surface dressings is suitable for roads with significant areas of stress.

8.2.2 Racked-in Surface Dressing (single binder spray double chipping application)

Binder is applied at a higher rate than for single dressing, and the primary size chippings (typically 14 mm on fast, heavily trafficked roads) applied at a lower rate are followed immediately by small chippings (6 mm) to fill the gaps and achieve mechanical interlock (see Figure 8.2). The advantages of the racked-in method are high initial texture depth, early stability of the dressing, and a major reduction in the initial loss of large chippings.

8.2.3 Inverted Double Surface Dressing (Pad Coat + Single Dressing)

Where the existing road surface is very hard or porous with high or variable macrotexture, a first dressing using small chippings (6 mm) can be made to provide a uniform softer surface to which the main dressing with larger chippings is applied (see Figure 8.3). It is common to leave the pad coat exposed to traffic for up to a year before applying the main dressing. The advantage of using a pad coat is that the main dressing chippings embed quickly, increasing resistance to chipping loss.

8.2.4 Double Surface Dressing (Double binder spray, double chipping application)

Binder is applied at a little less than the normal rate and normal size chippings (usually 14 mm) are applied at slightly less than the normal rate for a single dressing. A second application of binder and small chippings (6 mm) follows (see Figure 8.4). The advantages of the double spray double chipping method are moderately high texture depth, reduction in loss of large chippings, and the possibility of using larger chippings than would usually be selected for the road. Initial stability may be low, but builds up rapidly, and stressed areas must be treated using modified binders.

It is usual to allow extended time for rolling and curing of an emulsion binder before opening the dressing to traffic.

The use of double dressings - even where traffic flows are low - on exposed sites such as hills or mountains enhances durability, and is standard practice in some European countries. Double dressings are beneficial on high speed, heavily trafficked dual carriageways where slow speeds are used to orientate the chippings and form a mosaic are difficult if not impossible to ensure. Interlocked double dressing systems have a high initial stability, particularly when used in conjunction with premium grade binders.

Schematic Representation of the Types of Surface Dressing Prior to Embedment

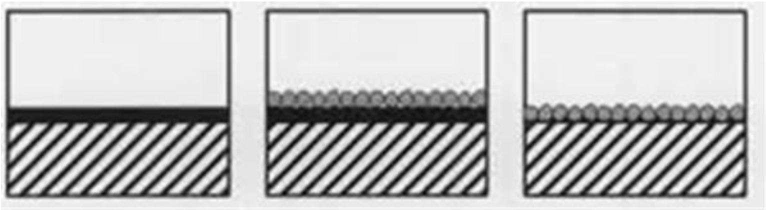

Figure 8.1: Single Surface Dressing

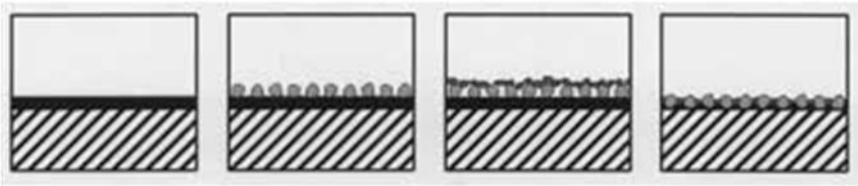

Figure 8.2: Racked in Surface Dressing

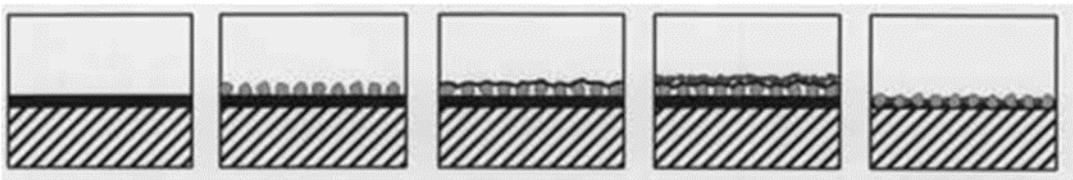

Figure 8.3: Inverted Double Surface Dressing (Pad Coat + Single Dressing)

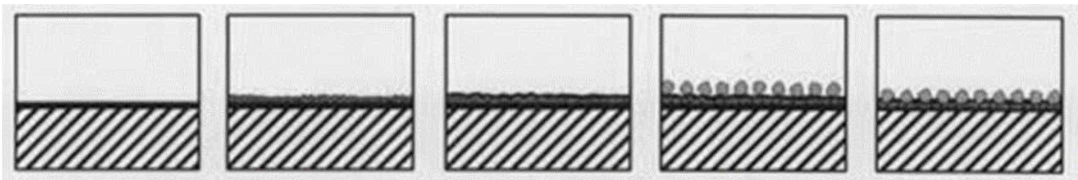

Figure 8.4 Double Surface Dressing

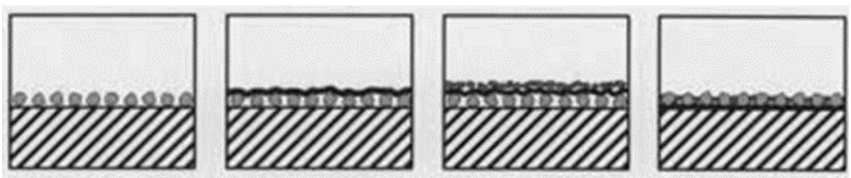

Figure 8.5 Pre-chipping Surface Dressing (Sandwich Surface Dressing)

8.2.5 Pre-chipping Surface Dressing (Sandwich Surface Dressing)

The primary chippings are applied first (typically 14 mm) followed by a single surface dressing (typically 6 mm chippings) (see Figure 8.5). It is important not to allow traffic to disturb the primary chipping layer, which has to be laid to close tolerances. This technique creates voids enabling the system to tolerate a binder-rich (or variable) surface, and allows a stable dressing to be constructed using larger than normal chippings.

8.3 Design

The requirements for surface dressing design are set out in DN-PAV-03074.

8.4 Specification

Surface Dressing shall be specified in accordance with CC-SPW-00900. The choice of the surface dressing to be designed and constructed shall be chosen from either Clause 7.2.2 or 7.2.3 of CC-SPW-00900 according to the division of responsibility between the Purchaser (Client, Local Authority, etc.) and the Producer (Contractor).

Recipe surface dressing requires a degree of expertise in and experience of the materials and processes. Recipe surface dressing may be used in the following circumstances:

i) Where the Purchaser has the expertise to design surface dressing, the resources to supervise the works and the desire to accept the additional risks associated with designing the product. No performance criteria can be specified such as visual assessment, macrotexture, etc.

ii) Where the Purchaser wishes to carry out trial or experimental surface dressing.

iii) Where the Purchaser wishes to carry out surface dressing in circumstances that are outside CC-SPW-00900 requirements, e.g. on extremely variable substrate or out of season work.

iv) Temporary works such as where skid resistance is needed for a short period.

Figure 8.6 below provides a flow diagram for planning and specifying surface dressings.

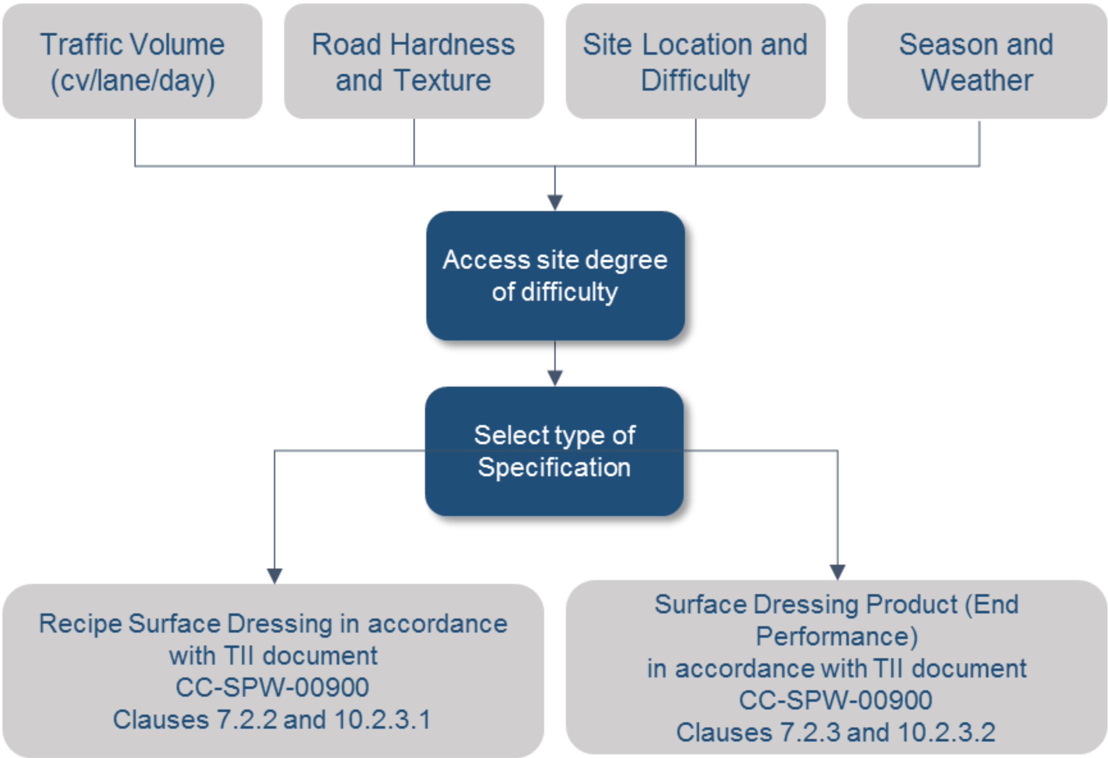

Figure 8.6 – Flowchart for Selection of Surface Dressing Specification

8.5 Properties

8.5.1 Environmental

The use of bituminous emulsion binders has been encouraged as they are environmentally friendly. The emissions from such binders are mainly water vapour and the installation is essentially a cold process having a low carbon footprint. Even hot applied emulsions are sprayed at temperatures around 80°C and the aggregate is normally at ambient temperature. This low spray temperature also results in minimal degradation of the polymer binder during storage and installation.

8.5.2 Speed of Works

The speed of surface dressing is a major asset for reducing road closure during maintenance. For single carriageway work with coned off sections and traffic control, outputs of 10,000m² per day are possible. With contra-flow and safety lanes output is really only limited by the supply of chippings to site and the frequency of testing as the binder sprayer is able to apply 10,000m² in approx. one hour. The ability to surface dress at night can minimise traffic disruption but can result in adverse noise and potential quality issues including the lower night-time pavement surface temperature.

8.5.3 Adhesion

The adhesion of a surface course to the underlying pavement structure is essential, particularly so with surface dressing. It is not thick enough to carry traffic induced stresses without excellent adhesion. Bond is even more important where there is a possibility of high braking and lateral stresses. Structural strength is only fully developed when all the layers in the pavement are well bonded, effectively forming a single layer.

8.5.4 Structural strength

Surface dressing does not strengthen the road pavement structure, although by reducing water ingress to the pavement the structural strength may be maintained.

8.5.5 Profile

Defects such as rutting and shoving must be eliminated before the surface dressing is applied, the dressing making no improvement to the road profile.

Soft patching materials, binder rich crack repair band sealing (including some hot screeded proprietary systems) and existing fatting in wheel tracks are likely to allow rapid embedment on heavily trafficked roads leading to early loss of texture.

8.5.6 Riding quality

There is no improvement in riding quality.

8.5.7 Noise

The high texture depth (macrotexture) achieved with surface dressing may cause an increase in noise level, especially in the very early life before any chipping embedment and mosaic formation have taken place. The use of multiple dressings or smaller chipping sizes reduces noise generation and are often specified for that reason.

8.5.8 Laying Season

Surface dressing has a very short laying season, particularly for heavily trafficked roads, although the advent of superior binder grades and improved processes has lengthened the season. The main reason for the short season is that the chippings have to adhere to the binder at temperatures close to ambient, while the binder must maintain sufficient cohesive strength to resist traffic forces when the road is opened.

8.6 Performance and Durability

8.6.1 General

Surface dressing has failed when it is either:

a) No longer able to meet the needs of the traffic using the surface; or

b) No longer protecting the structure of the carriageway from the ingress of water.

Failure occurs in one of three different and rarely overlapping time periods: during construction or shortly afterwards caused by extremes of weather and/or poor traffic management; during the first couple of years; or due to old age, which may be any length of time from 5 years after laying. Records exist of surface dressing performing satisfactorily in excess of 20 years.

Early failures are almost always the result of inadequacies in one or more of the 4 stages in the production of a surface dressing on the road. The stages are:

a) Specification.

b) Design.

c) Materials.

d) Execution including aftercare.

All surface dressings fail eventually. This is due to a combination of factors including principally: embedment of chippings, fretting or wear of chippings and binder hardening. This long term failure is rarely catastrophic and appropriate maintenance surface treatment can be planned in advance. Surface dressings do not fail on a fixed time basis and each site should be inspected regularly and treated at the appropriate time.

8.7 Design of Special Applications - Surface Dressing on Asphalt Concrete

Asphalt concrete may require surface dressing to ensure good skid resistance. It is recommended that the surface dressing be carried out on asphalt concrete as soon as practicably possible, when the mat has cooled to ambient temperature and, subject to the works being undertaken within the weather condition requirements of Clause 10.2.3.1.8 of CC-SPW-00900. Polymer modified emulsion shall be used for such works with a minimum peak cohesion of ≥ 1.2 J/cm^2 to IS EN 13588.

Asphalt concrete surfaces are typically porous to one degree or another, and each site must be evaluated by visual inspection for the degree of porosity if a surface dressing is to be employed. When conducting the hardness test, some asphalt concrete may give deceptively soft results in warm conditions. Unless the road surface is visibly binder rich, with low texture (< 0.5mm), or very little coarse aggregate is visible at the surface, then the asphalt concrete should be treated as 'hard' and a ball penetration figure of 1mm should (or 3mm for CTRA probe) should be used for design purposes on such surfaces. If is not possible to take meaningful hardness readings on high void content asphalt surface courses such as porous asphalt, stone mastic asphalt and thin layer surfacings; these should also be treated as hard.

There are three possible design solutions:

1. Seal and Single Surface Dressing,
2. Seal and Racked-In Surface Dressing, or
3. Seal and Double Surface Dressing.

Single surface dressings are only appropriate for older or close textured asphalt concrete on sites with very low traffic (< 25 cv/lane/day).

The recommended sizes of chips for each of the surface dressing types is shown in Table 8.1. The design of the surface dressing shall follow the procedures described in Chapter 4 of DN-PAV-03074.

The pre-treatment seal using a 2/6 chipping before the main surface dressing is required on more porous or variable asphalt concrete surfaces, and is recommended for fresh laid asphalt concrete (less than 3 months old). The aim is to seal up the porosity of the asphalt concrete so that the binder in the main surface dressing will not soak away, leaving insufficient binder to hold the primary chippings. Where asphalt concrete pavements are laid late in the surface dressing season it may be preferable to seal them with a pad coat using a 2/6 chipping and apply the final surface dressing during the following season. The design for the pre-treatment layer shall be based on the Designer's observation of the existing road condition as set out in Chapter 4 of DN-PAV-03074.

If the ALD of the 2/6 chipping is known, the pre-treatment layer can be designed using the analytical procedure in Chapter 4 of DN-PAV-03074. Where the ALD of the 2/6 chip is not known, the rate of spread of binder for the pre-treatment layer should be 0.6 to 0.9 L/m^2. The 2/6 chippings should be spread so that there is an excess, and typically in the range 3.5 to 4.5 L/m^2.

The light rate of spread of binder for the pre-treatment sealing layer, combined with the risk of the excess 2/6 chippings being ground into dust, may require that the seal plus surface dressing layers be laid on the same day, with the minimum of trafficking between the applications.

A bond coat of emulsion in the oil track at 0.3 to 0.6 L/m^2 will help to prevent localised stripping between the wheel tracks on roads with very channelised traffic. This bond coat should be applied after the pre-treatment layer. The bond coat shall comply with CC-SPW-00900.

Table 8.1: Surface Dressing Fresh Asphalt Concrete, Type and Chipping Size

Surface Dressing Fresh Asphalt Concrete (*)	Chipping Size (mm)		
	Pre-treat	First Layer	Second Layer
Seal and Single Surface Dressing	2/6	6/10	n/a
Seal and Racked-In Surface Dressing	2/6	10/14	2/6 rack-in
Seal and Double Surface Dressing	2/6	10/14	2/6
		10/14	6/10

(*) Use only Polymer Modified emulsions

8.8 Assessment of Road Hardness

The road hardness should be measured using the Ball Penetration method as described below and outlined in DN-PAV-03074 Chapter 4. Traditionally, the CTRA (Coal Tar Research Association) probe, which uses spring loaded penetrometer with a 4mm hemispherical head, has been used to measure road hardness in Ireland. International experience indicates that the narrow head on the CTRA probe tends to displace chips and may give inconsistent/misleading results. The Ball Penetration test consists of measuring the penetration that a 19mm steel ball bearing makes in the existing road surface when it is struck by one blow of a Marshall compaction hammer. Figure 8.7 shows a comparison of the CTRA 4mm probe head and the 19mm ball bearing used in the ball penetration device.

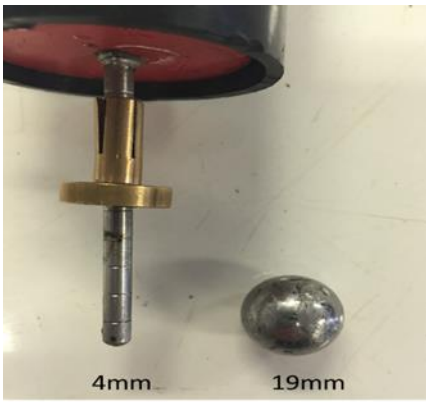

Figure 8.7: CTRA 4mm Probe Head and 19mm Ball Bearing

8.8.1 Ball Penetration Device

The Ball Penetration device uses a 19mm diameter steel ball bearing which is driven into the road surface by a single blow from a Marshall hammer, and the depth of penetration of the steel ball into the road surface is measured. The ball penetration device was originally developed in South Africa and is described in South African National Standard (SANS) 3001-BT10: 2013 'Ball penetration test for the design of surfacing seals'. The South African Hammer (SAH) device consists of multiple parts including a circular tripod stand, a steel cross-bar, a standard Marshall compaction hammer, a 19mm ball steel bearing, and a method to measure the depth of penetration (depth gauge or steel rule, 0.5mm units) of the steel ball.

The ball penetration device used in Australia is a modified version of the South African Hammer device and incorporates all the necessary parts in a single frame resulting in simpler operation and handling. The Australian Modified Hammer (AMH) is shown in Figure 8.8. The AMH device is operated in accordance with the Austroads standard AG:PT/T251-10 'Ball Penetration Test'. The AMH has a built-in weight which is dropped from a given height onto a detachable 19mm ball bearing hemispherical foot at the bottom of the device, as shown in Figure 8.9.

The built-in weight conforms to the Marshall hammer mass and drop height. The 19mm ball bearing should be carefully positioned to ensure that it is placed in a depression between aggregate particles on the road surface during testing.

The ball penetration device has a built-in spirit level to ensure the device is vertical during testing. The device has a penetration reading gauge engraved on the upper end of the sliding bar and an external dial gauge with a digital display for the measurement of penetration depth. An electronic thermometer to measure temperature is also required as part of the test.

The test procedure involves carrying out 5 ball penetration tests at 100mm intervals at a randomly selected location within each area of similar condition and representative of the site to be surface dressed. The 5 readings are averaged and a correction applied for the measured pavement temperature as outlined in Austroads standard AG:PT/T251-10.

The hardness of the road surface is temperature dependent based on the type of surfacing material and local climatic conditions. Ideally, the surface temperature of the road should be between 20ºC and 30ºC when conducting the road hardness measurements.

For each test, the road surface temperature is measured, and the average ball penetration value at the temperature of test for each test location is corrected to 25ºC using the following formula:

Pen Ts = Pen Tt - K (Tt - Ts)

where:

Pen Ts = the temperature corrected ball penetration value (i.e. to 25ºC).

Pen Tt = Penetration depth at time of test (mm).

Tt = Temperature of the road surface at the time of test (ºC).

Ts = Standard summer temperature of road for the region (taken as 25ºC).

K = Temperature susceptibility of surfacing (mm/ºC).

The recommended K factors (SANS: 3001-BT10 and AG: PT/T251-10) are:

- single and multiple seals (not fatty) 0.04 mm/ºC
- primer seals (not fatty) 0.06 mm/ºC
- fatty roads and asphalt surfacings 0.08 mm/ºC

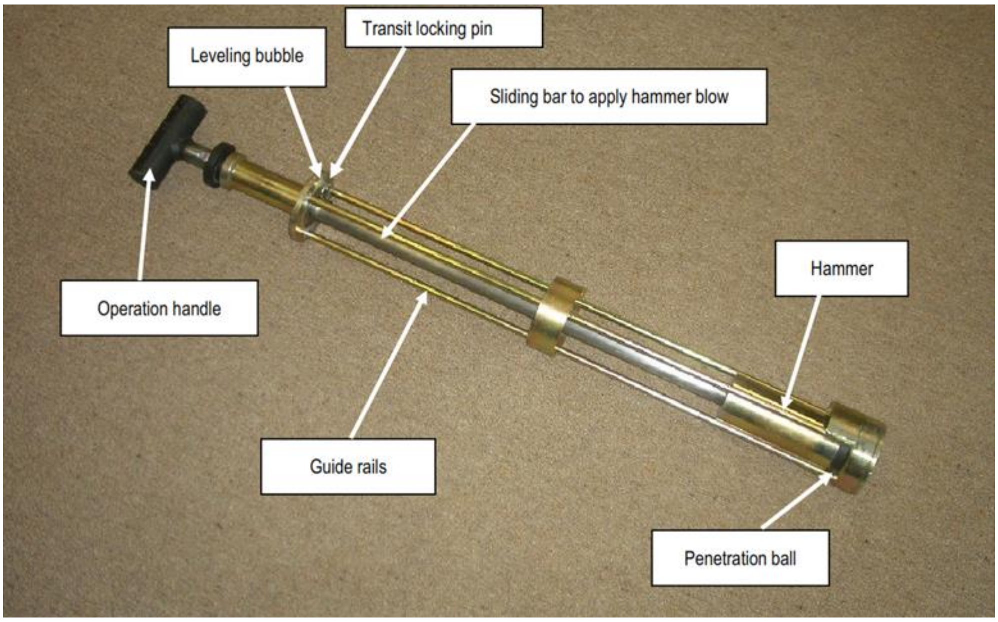

Figure 8.8: Ball Penetration Device (Austroads AG: PT/T251-10)

Figure 8.9: Detachable 19mm Penetration Ball and Base (Austroads AP: T90/07)

8.8.2 CTRA Road Hardness Probe

The CTRA road hardness probe is shown in Figure 8.10. The test procedure for the CTRA probe is described in BS598: Part 112 “Method for use of road surface hardness probe” and TRL Road Note RN39 “Design guide for road surface dressing” (7th edition). A timer, steel rule and electronic thermometer are also required as part of the test apparatus

The CTRA probe is a handheld spring-loaded penetrometer with a 4mm diameter approximately hemispherical tip. The tip is pushed into the road surface by hand, whereby an internal spring is compressed until the upper end of the probe head rises through the casing and is felt by the palm of the operator’s hand. A target force of 350N is imparted to the pavement surface by the probe during testing, and the required loading should be applied for 10 seconds. International experience indicates that the narrow head tends to displace chips and may give inconsistent/misleading results. In addition, it can be difficult to maintain the probe in a vertical position while applying a considerable force with one hand.

To carry out the test at each location, measurements are made using the method described in BS598: Part 112 (typically 10 readings are taken at 0.5 m intervals along a longitudinal line in the nearside wheel track of each lane). The average of the 10 readings is reported as the mean penetration at the measured road surface temperature, which should preferably be between 15ºC and 30ºC. The road hardness at 25ºC is then determined using the graph for surface temperature Category B given in Road Note 39. Category B represents Central England, Wales and Northern Ireland and was chosen as this category would be the most similar to Irish climatic conditions. The graph for surface temperature Category B is shown in Figure 8.11.

In the absence of the Ball penetration device, the corrected CTRA reading can used in the analytical design process as set out in Annex A of DN-PAV-03074 Chapter 4.

Figure 8.10: CTRA Probe

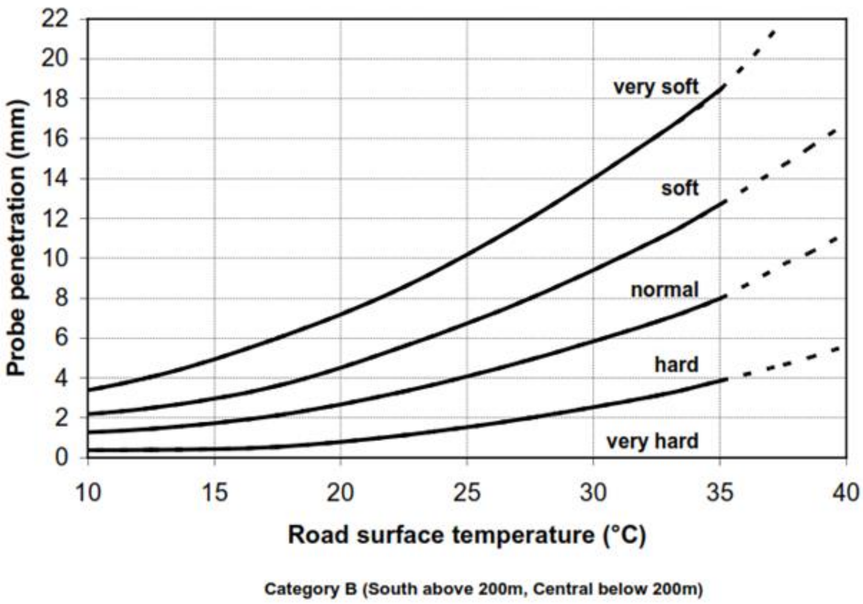

Figure 8.11: Temperature Correction for CTRA Device (RN39)

8.8.3 Road Hardness Information to be Recorded

The information to be recorded at each test location included:

a) Name of operator
b) Road surface type
c) Description of surface condition being tested (homogeneous, fatted up or ravelled)
d) Road gradient (flat, steep uphill or steep downhill)
e) Test position (left or right wheel track, between wheel tracks, shoulder, centreline)
f) Air temperature and road surface temperature
g) Report the individual penetration values to the nearest 0.5 mm
h) Report the average ball penetration value to the nearest 0.5 mm

The information can be recorded on the data collection form shown in Annex A.

8.9 Background to Analytical Design Procedure

8.9.1 Introduction

The analytical design approach has been derived using some of the principles set out in the New Zealand Chipsealing Manual. The methodology is based on work originally conducted by F M Hanson (1935) who developed an engineering approach to the selection of optimum rates of spread of binder and chippings, and is similar to the basis of analytical design methods for surface dressings adopted in Australia and South Africa.

The analytical approach considers the volume of voids between the chippings after spreading and rolling, and the orientation the chippings adopt after trafficking. Hanson found that after construction and trafficking compaction, chippings will orient to the flattest direction and thereby adopt a more stable position whereby their least dimension is vertical, hence giving rise to the concept of Average Least Dimension (ALD). To ensure that the aggregate chips are not submerged in binder during service, the average least dimension of the aggregates is used to determine an appropriate rate of spread of aggregate and binder.

Hanson calculated that in a loose single layer of chippings for surface dressing that the voids are initially about 50% decreasing to about 30% after rolling and subsequently to 20% under the action of traffic. For best results, between 65 and 70% of the voids in the compacted aggregate should be filled with binder. The average depth of the aggregate layer after construction and traffic compaction is approximately equal to the ALD of the aggregate chippings used. The three stage process is outlined in Figure 8.12.

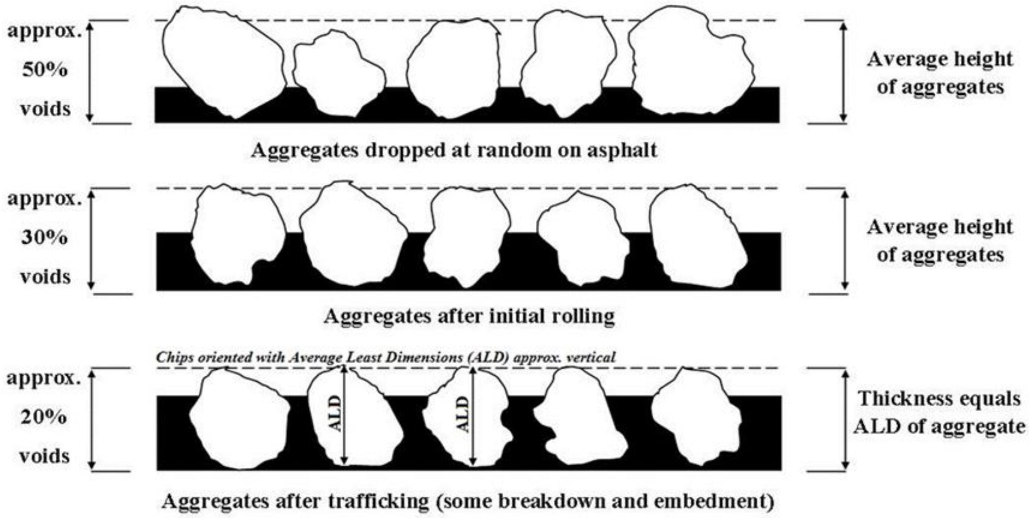

Figure 8.12: States of Embedment of Surface Dressing Chippings (Hanson 1935)

8.9.2 Chip Shape: Average Least Dimension of Surfacing Chippings

The Average Least Dimension (ALD) which takes into account the size and shape of the surfacing chippings is an essential parameter in the analytical design of surface dressing. The least dimension of an aggregate particle is the smallest perpendicular distance between two parallel plates through which the particle will just pass. The average least dimension is the arithmetic mean of all the measured least dimensions of the aggregate particles measured.

There is significant overlap with the flakiness index, used for many years as an aggregate characteristic in surface dressing design, but international practice has shown that the flakiness index alone does not fully capture the shape properties required and that the ALD provides a better measure of chip shape than the flakiness index alone. The ALD takes account of the flakiness index and grading of the surfacing chippings and allows the designer to better determine the rate of application of binder and rate of spread of chippings necessary for a particular shape of chip.

The concept of an aggregate particle tending to lie with its least dimension vertical is central to the analytical design of a surface dressing. As shown in Figure 8.13, the shape is most stable when lying with its least dimension (A) vertical. If placed with the width (B) or depth (C) of the shape vertical, it would require less energy to knock the aggregate particle over so that the least dimension (A) was again vertical, particularly if the particle is other than cubic. Thus in a surface dressing, the final orientation of most particles is such that the least dimension is near vertical, providing that there is sufficient space (provided by the aggregate spread rate) for the particles to realign. In the case of almost cubical aggregates the least dimension may be only marginally smaller than the other two dimensions, or can be much less in the case of flaky aggregates.

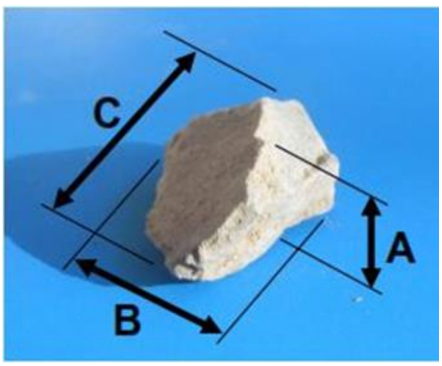

Figure 8.13: Three Dimensional Shape of an Aggregate Chipping (Austroads 2006)

The ALD can be determined by direct measurement of a representative batch of surface chippings, or can be accurately and more easily calculated using the Dumas Method from the grading and flakiness index of the surfacing dressing chippings.

The direct measurement method involves measurement by hand on a representative sample of chippings (200 chips) using a Vernier calipers or an automatic ALD measuring apparatus in accordance with the South Africa test standard TMH1 Method B18(a).

The Dumas computational method is outlined in the South Africa test standard TMH1 Method B18(b)T. The Dumas calculation has been developed as a Microsoft Excel spreadsheet, with the calculated ALD derived directly from the full gradation analysis and the flakiness index data. The aggregate chippings should comply with Clause 7.2.2.1.2 of CC-SPW-00900. The grading analysis should be carried out in accordance with IS EN 933 Part 1: 2012, and the flakiness index determined in accordance with IS EN 933 Part 3: 2012.

The ALD determined by either the direct measurement or Dumas method can be used in the analytical design method, but the Dumas approach is recommended as the ALD can be more easily and readily calculated from the grading and flakiness index.

The importance of using a representative ALD in the design process cannot be overemphasised. Poor sampling techniques and/or inaccurate testing procedures to determine ALD will result in inaccurate design binder application rates and incorrect aggregate design spread rates. It is poor practice to use assigned or nominal values of ALD for a particular nominal size of aggregate. ALD of individual aggregate stockpiles can vary significantly within normally specified ranges of grading and flakiness index, resulting in an equivalent variation in the design rates of basic binder application and aggregate spread rate. It is thus important to monitor the ALD of aggregate stockpiles regularly within a sufficiently comprehensive sampling scheme to progressively evaluate whether surface dressing design changes are warranted.

8.9.3 Dumas Computational method for ALD

The Dumas computational method is outlined in the South Africa test standard TMH1 Method B18(b)T, and has been developed as a Microsoft Excel spreadsheet. The Dumas approach characterises the particle size distribution based on percentage passing and percentage retained on five sieves, rather than the single interpolated sieve used to define median particle size. The Dumas approach is based on examination of the percentage retained (PR) from the gradation analysis for five different PR values, 10%, 25%, 50%, 75% and 90%. The PR values are used to determine the degree of peakiness (K-value) and degree of symmetry (S-value) which are used together with the median value (Me), flakiness index (Fi) and fraction not measured (Fr) to calculate the ALD. The calculation process described by Dumas is quite complex, but has been developed for ease of use through a Microsoft Excel spreadsheet, with the calculated ALD values derived directly from the gradation analysis and flakiness index results. An Example of the Excel spreadsheet is given in Annex B of DN-PAV-03074 Chapter 4.

8.9.4 Chip Shape: Average Greatest Dimension of Surfacing Chippings

The volume of voids in a surface dressing is higher when more cubical chips are used, and the binder application rate needs to be increased to allow for chips with more cubical shape. The size and shape of chipping is currently assessed using the grading, flakiness index and ALD. In addition, TII are also considering the introduction of the average greatest dimension (AGD) parameter to improve the evaluation of chip shape. The determination of AGD is outlined in the Transit New Zealand test standard TNZ T/5:1987. Research is needed to investigate the AGD values and the ALD/AGD ratio that will be used to control chip shape for Irish aggregates used in surface dressing.

8.9.5 Analytical Design Algorithm

The algorithms for surface dressing design developed in New Zealand (2004) will be adopted for the derivation of the residual binder volume (i.e. the bituminous residue after the evaporation of water and any particulates within the binder). The following sections outlined the background theory to the design algorithms. The design inputs to determine the basic residual binder volume include traffic volume, chip ALD, texture depth and number of days to first major frost.

8.9.5.1 Traffic

Traffic volume, and in particular commercial vehicles, has an important influence on the performance of surface dressing and plays a key role in the initial bedding down of the surfacing. Traffic shall be calculated in terms of the Equivalent Light Vehicles (ELV) per lane per day using the following formula which assumes the influence of a commercial vehicle as equivalent to ten light vehicles.

T_{ELV} = AADF x (1 + (0.09 x %HCV)) Equation 8.1

where:

T_{ELV} = Equivalent Light Vehicles per lane per day

AADF = Annual Average Daily Flow in vehicles per lane per day

%HCV = Percentage of heavy commercial vehicles

8.9.5.2 Voids Concept

The spaces (voids) between the surface dressing chips can be regarded as consisting of air, binder, and substrate which is related to the amount of chip embedment and this is shown on Figure 8.14.

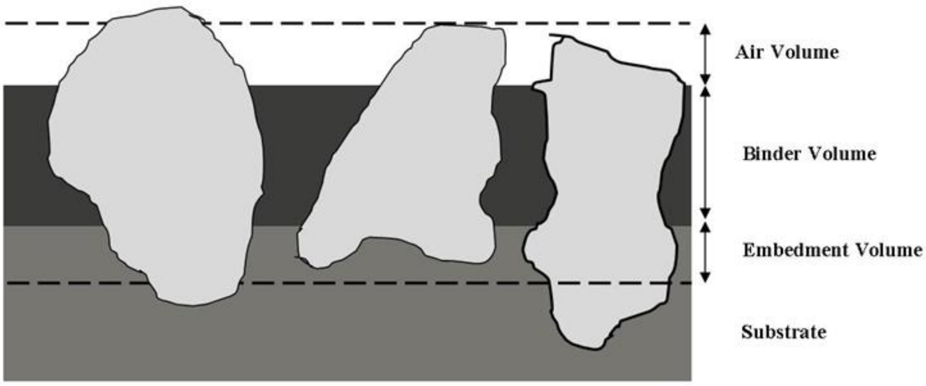

Figure 8.14: Voids Concept in a Surface Dressing (Potter and Church, 1976)

Under traffic, the voids decrease in volume as the chip becomes re-oriented and embedded in the substrate and leads to reduced texture. The extent that the chip embeds into the substrate is a function of the pavement surface hardness.

The volume of voids VV can be expressed as follows:

$V_V = V_B + V_{AIR} + V_E$ Equation 8.2

where:

V_V = Volume of Voids

V_B = Volume of binder

V_{AIR} = Volume of air or texture depth

V_E = Volume of chip embedment

8.9.5.3 Derivation of the Residual Binder Volume

The algorithms for surface dressing design developed in New Zealand (2004) for the derivation of the basic residual binder volume are as follows:

Single surface dressing

$V_V = ALD\ (0.83 – 0.07\ \log10\ (T_{ELV} \times D_F))$ Equation 8.3

Racked-in or Double surface dressing

$V_V = ALD\ (0.99 – 0.08\ \log10\ (T_{ELV} \times D_F))$ Equation 8.4

Based on the requirement to have 35% of the voids filled at the beginning of winter, the design algorithm can be expressed as follows:

$V_B = 0.35\ V_V$ Equation 8.5

The amount that the chip interlocks is a function of the chip sizes being used and the texture depth of the existing surface. The chip interlock embedment is assumed at 30%, and the ALD of the chip is therefore increased by 0.7 x T_D, in the algorithm, where T_D is the texture depth of the existing surface. Using this together with equation 8.5, the surface dressing algorithms for determining the basic residual binder volume can be expressed as:

Single surface dressing

$V_B = (ALD + (0.7 \times T_D)) \times (0.291 – 0.025\ \log_{10}\ (T_{ELV} \times D_F))$ Equation 8.6

Racked-in and Double surface dressing

$V_B = (ALD + (0.7 \times T_D)) \times (0.347 - 0.029 \log_{10} (T_{ELV} \times D_F))$ Equation 8.7

where:

V_B = Basic residual binder volume (L/m^2)

ALD = average least dimension of the surfacing chippings

T_D = is the texture depth (mm) of the existing surface

T_{ELV} = ELV per lane per day

D_F = Number of days to first major frost

Equations 8.6 and 8.7 are used in the analytical design procedure as outlined in DN-PAV-03074 Chapter 4.

8.10 Pre-treatment Options

The surface dressing design shall be applied to a homogeneous section of pavement in terms of traffic, texture, hardness and site conditions/stress. Pre-treatments can be used to prepare a surface before surface dressing, as it is important to reduce any variation that has arisen during its life. If the road hardness, texture or substrate varies along a section of road, significant structural defects or visual differences in the surfacing are present, or there are significant differences in traffic or other factors, where practicable, pre-treatment of the existing road prior to surface dressing should be carried out to form homogeneous sections of sufficient length for surface dressing.

The responsibility for the installation of any pre-treatment works shall be clearly defined as that of the Producer or the Purchaser.

Pre-treatment works may include surface preparation works to achieve the minimum macrotexture required prior to application of the surface dressing and/or surface/structural repair in accordance with CC-SPW-00900. Examples of pre-treatments include pre-gritting wheel tracks, pre-spraying oil tracks, high pressure water or mechanical abrasion treatments to reinstate texture or sealing the road surface. The pre-treatment option for different surface conditions are outlined in Table 8.2. Such pre-treatment methods should not adversely affect the existing surface.

Methods of pre-treatment are available for reinstating surface texture or for reducing the variation in texture of a surface before surface dressing, some of which do not include pad coats, for example using high pressure water treatments.

Table 8.2: Pre-treatment Options

Surface Type	Description	Possible Pre-Treatment
Binder lean/Porous	Surfaces like porous asphalt and open textured asphalt concrete.	Pad coat surface dressing with 2/6 chippings some weeks before the main dressing (or even the previous season).
Rough	A surface with a texture depth > 1.0mm, usually with some fretting.	Application of microsurfacing and/or mechanical surface treatments to normalise or reduce texture.
Normal homogeneous	Minimal variation in appearance over whole section and texture depth ≤ 1.0mm. Hardness is normal.	None needed.
Soft homogeneous	Minimal variation in appearance over whole section and texture depth < 1.0mm. Hardness is soft or very soft.	None needed.
Fatted up	Has an area on surface layer of free bitumen, usually limited to the wheel tracks.	If it is only in the wheel tracks and has taken at least 5 years to develop then it is worth removing the excess binder with high pressure water jetting.
Bleeding	Has a surface layer of free bitumen, usually extending beyond the wheel tracks and often happens soon after a surface dressing has been applied.	No pre-treatment will avoid subsequent failure, in very bad cases even on virtually untrafficked roads
Heterogeneous, tracked	This is the normal state of surface which has been previously surface dressed; because of the difference in texture and traffic across the lane it is possible to optimise design for texture in the wheel track or chip retention in the untrafficked areas.	See Fatting up above
Heterogeneous, patched	This occurs mainly in urban areas where most roads are subject to opening by statutory undertakings companies with subsequent reinstatement using materials which may have significantly different properties of porosity and hardness from the surrounding road surface.	The problem is best reduced to a minimum by insisting on proper reinstatement with materials which match the hardness and porosity properties of the existing road. Low speed roads which are badly affected can sometimes benefit from a pre-treatment with a microsurfacing. The microsurfacing will have a low macrotexture and will have to be left to mature for a sufficient period before surface dressing; otherwise it will be very soft.

8.11 Recipe surface dressing Design Report

The Purchaser shall carry out and prepare a surface dressing design report specific to site. This design report shall include relaxations and departures from Standards.

The Purchaser shall retain the recipe surface dressing design report and include with as built records prepared in accordance with CC-CMG-04001 along with full records of all test results.

The purpose of the recipe surface dressing design report is to present a design option taking account of the specific site characteristics and constraints. The design details proposed shall generally comply with DN-PAV-03074. The materials and method of work proposed shall comply with the CC-SPW-00900.

A Recipe Surface Dressing Design Report will typically include the following:

a) The need for the proposed scheme; this should highlight the pavement surfacing issues which are to be addressed, for example, existing pavement condition, existing defects, existing horizontal/vertical alignment elements, existing cross-section, etc. The list of data to be gathered are outlined in AM-PAV-06049 and AM-PAV-06050.

b) Specific objectives of the proposed scheme.

c) Collision history and records.

d) Design speed calculations as per DN-GEO-03031.

e) Design traffic as per PE-SMG-02002

f) Options considered.

g) Cost-benefit analysis (undertaken prior to design stage)

h) Recipe surface dressing design proposed

i) Constraints; existing constraints including environmental constraints should also be identified.

j) Geometric features (existing and proposed); horizontal alignment, vertical alignment, cross-section, gradients, cross-falls, superelevation, stopping sight distances, full overtaking sight distances, etc.

k) Drainage requirements.

l) Traffic signs and road marking requirements.

m) Junction treatment (if applicable).

n) Requirements of non-motorised users.

o) Preliminary design drawings.

An example of a Recipe Surface Dressing Design Report summary and checklist is given in Annex B.

9. High Friction Surfacing

9.1 Introduction

High Friction Surfacing (HFS) has a long history of imparting the highest level of skid resistance onto a road surface. The concept was first investigated in the USA during the 1950's using epoxy resin binders and calcined bauxite aggregate in order to achieve a level of skid resistance not achievable by normal aggregates.

There are two types of system, hot applied and cold applied. The hot applied system achieves adhesion through heat application to the road surface whilst the cold applied system achieves by adhesion to the road surface through chemical bond. Cold applied systems remain workable for longer periods during installation compared to hot applied thus giving the Contractor more time to ensure all workmanship issues and quality requirements are managed. The cold applied technique involves the even application of a polymeric liquid binder onto the road surface followed by the application of calcined bauxite aggregate. The hot applied systems involve the application of a hot pre-mixed material consisting of a resin binder matrix incorporating calcined bauxite aggregate.

HFS, and indeed any surfacing, cannot compensate or correct adverse alignment or drainage problems. The main issue is to understand the cause of accidents at the site in question, whether it is speed, geometry, camber or other factors before making the surfacing decision. Consequently, prior to the application of HFS, the characteristics of the site need to be evaluated to determine if other road engineering issues, such as improvements in signage, road markings, camber, alignment or drainage could be adopted to reduce the hazard which might provide a better long term solution.

It should be noted that the adoption of HFS may encourage drivers to rely on the additional grip and consequently increase speeds. The conspicuity of HFS may lead to certain drivers exploiting its potential when they are aware that it offers the highest level of skid resistance. This is a constant concern for those with responsibility for highway safety. This concern is a result of experiences at some sites where accidents have increased after treatment.

Where a SMA surfacing is used on the circulatory part of a roundabout, a maximum nominal aggregate size of 10mm should be used in the surfacing as research has demonstrated that this will provide greater durability. High friction surfacing should not normally be used on roundabouts.

HFS must be used appropriately and sparingly. The use of HFS is therefore limited and shall only be permitted at the locations specified in Table 4.1 of DN-PAV-03023. Further guidance on this is provided in DN-PAV-03074.

HFS does not contribute to the structural performance of the pavement and can only be applied to substrate that are in good condition and free from cracking and joints.

HFS is expensive and has a very high carbon footprint which is mainly due to the method of production of the raw materials.

The type of application, how the materials are applied, preparation and the prevailing ambient conditions at the time of installation are important to ensure long term durability of the product.

The adhesion of a HFS to the underlying pavement structure is essential, particularly so with high friction surfacing, and their application can be weather dependent.

It is not thick enough to carry traffic induced stresses without excellent adhesion. Bond is even more important where there is a possibility of high braking and lateral stresses. Structural strength is only fully developed when all the layers in the pavement are well bonded, effectively forming a single layer.

Aggregates can be derived naturally or manufactured. Calcined bauxite is a commonly used manufactured aggregate that has a proven track record as an effective high friction surfacing aggregate.

Although the calcined bauxite used in HFS must have a high PSV, a large factor is the size of the aggregate (3 mm) and other, natural, aggregates of this size have PSVs in excess of 70 (see TRL 322). The advantage of calcined bauxite is that it is extremely hard and wears away very slowly under traffic.

9.2 Design

The requirements for HFS design are set out in DN-PAV-03074.

9.3 Specification

HFS shall be manufactured, delivered and laid in accordance with CC-SPW-00900. Reference should also be made to the requirement for a prTAIT as set out in DN-PAV-03075.

9.4 Properties

9.4.1 Cold Applied HFS

These systems comprise a resin (thermosetting) binder which also acts as an adhesive for the aggregate, typically graded 1-3mm. The aggregate is very hard with a low Aggregate Abrasion Value (AAV) and a high Polished Stone Value (PSV) that provides the necessary friction with the tyre.

Note: in some cases, the binder may be sprayed warm but the aggregate is always laid cold.

Cold applied resins include epoxy resin, bitumen extended epoxy resin, polyurethane, polyurea, and methyl methacrylate. Cold applied resins are installed as continuous films of adhesive. They are either:

a) Blended and sprayed by machine onto the road onto which the aggregate is broadcast, or

b) Blended mechanically and then manually applied by a squeegee after which the aggregate is broadcast.

Note: In both cases, after the resin has cured, excess aggregate is removed by sweeping.

9.4.2 Hot Applied HFS

Hot applied binders are essentially thermoplastic products and include rosin ester and hydrocarbon resin. The pre-mixed resin and aggregate is heated in a truck mounted boiler at high temperature ensuring the material is mixed and workable. The hot thermoplastic material is screeded out in strips to cover the whole surface.

9.5 Performance and Durability

HFS have a low service life of typically 3-6 years. They are consequently not always a suitable solution from an asset management perspective. In addition, they may not be the most appropriate solution as there may be other engineering factors such as drainage, or alignment, or improved signage that could provide an equal and more durable solution and other engineering solutions should be considered as noted in section 9.1 paragraph 3.

As HFS is generally used in high braking zones the bond is extremely important due to the possibility of high braking and lateral stresses breaking the bond with the underlying pavement. This is one of the most frequent failure mechanisms for HFS. It should be noted that HFS bonding with concrete substrates is generally more difficult than with bituminous substrates.

10. Low Energy Bound MIXTURES

10.1 Introduction

Low Energy Bound Mixtures (LEBM) are materials bound with low energy binders such as cement, foamed bitumen, or bitumen emulsions. Assuming that the LEBM can achieve the desired performance, the material can be potentially used as a subbase, base, and binder courses. It has the advantage of being able to use significant amounts of recycled materials and can be produced ex situ (in a fixed or mobile mixing plants) or in situ by machinery capable of pulverising and reconstituting the existing road pavement.

The aggregates used in LEBM can be sourced from quarries, recovered materials from existing pavements, or a blend of both types. The key issue is to ensure an optimum grading for the final material. Once compacted and shaped, the LEBM layer can be overlaid with a bituminous mixture or a surface dressing. In a base layer, the LEBM offers improved structural characteristics which generally requires less expensive bituminous mixture overlays.

CC-SPW-00900 requires the use of use of cement as a binder in all cases, either exclusively or combined with foamed bitumen or bitumen emulsion. This is based on experience of a number of trials in Ireland where the addition of cement has been found to be advantageous in permitting early trafficking and extending the laying season for the material.

Pavements constructed with LEBM are cost effective and have considerable environmental benefits including significant energy savings through reduced heating and haulage requirements. LEBM may also be manufactured using secondary aggregates recovered from site minimising the use of virgin aggregates. The secondary aggregates can form 100% of the LEBM or be mixed with a proportion of virgin aggregate to achieve the optimum grading of the material.

In pavement rehabilitation works, in situ recyclers can be used to produce and install LEBM, however the ex situ process allows for more accurate control of the input materials, quantity of mixing and for stockpiling of materials prior to batch mixing of the material.

South Africa is one of the leaders in LEBM and the reader should refer to the Technical Guidelines on Bitumen Stabilised Materials published by the South African Asphalt Academy for some background information on LEBM materials and processes.

LEBM materials differ from the application of Hydraulically Bound Materials (HBM) materials which are specified in CC-SPW-00800. HBM's are defined as materials that set and harden in the presence of water and the use of bituminous binders is excluded from the mix. HBM include a range of Cement Bound Granular Mixtures (CBGM) and soil cement which can be used for subbases or as base material in composite pavement designs.

The following factors need to be considered for each site to determine the most appropriate maintenance treatment:

a) Proximity of suitable location for setting up ex situ plant.

b) Proximity of sources of alternative materials, if required.

c) Types and severity of deterioration.

d) Extent of deterioration.

e) Location of services within the pavement construction.

f) Condition of drainage.

g) Edge detail and verge condition.

The suitability of LEBM depends on a large number of factors. The chief criterion for the selection of rehabilitation treatments will be an economic one. However, if LEBM are uneconomic compared to treatments using conventional hot mix materials, the case for low-energy pavements may still be viable provided that there is an appropriate policy for low-energy and recycling treatments as part of a wider sustainability campaign. Further guidance on this is provided in DN-PAV-03074.

10.2 Design

The requirements for LEBM design are set out in DN-PAV-03074.

10.3 Specification

LEBM pavement courses shall be manufactured, delivered and laid in accordance with CC-SPW-00900.

10.4 Properties

The main properties of LEBM include the following:

a) An increase in cohesion compared to the parent material.

b) Increase in flexural strength due to the visco elastic properties.

c) Increase in moisture resistance within the pavement.

d) Compared to bituminous mixtures, LEBM are not overly sensitive materials and small variations in both the amount of bitumen added and untreated material properties will not significantly change the strength achieved through treatment. This allows some limited variability in the recycled material to be tolerated.

10.5 Families of LEBM

The principal binders for LEBM are Portland cement, foamed bitumen and bitumen emulsion. Materials bound with cement tend to cure more quickly than bitumen bound materials and foamed bitumen or bitumen emulsion are likely to be less susceptible to shrinkage cracking than hydraulically bound materials.

LEBMs are classified according to the primary binder type. Requirements for product composition and properties of LEBM with respect to binder contents are detailed in CC-SPW-00900. The four material classifications are defined as:

a) Bitumen Stabilised Materials (BSM) with bituminous and hydraulic binder(s) including cement.

b) Cement-Bitumen Treated Materials (CBTM) with bituminous and hydraulic binder(s) including cement, similar to BSM but with higher hydraulic binder content.

c) Cement Treated Mixtures (CTM) with hydraulic binder(s) only including cement.

d) Cold Asphalt Mixtures (CAM) with bituminous and hydraulic binder(s) including cement. CAM are similar to BSM but have a higher bituminous binder content.

10.5.1 Bitumen Stabilized Mixtures (BSM)

BSM are produced using bitumen emulsion or foamed bitumen as the stabilizing agent. The bitumen addition usually does not exceed 3% by mass of aggregate. A small amount of cement or other additives, minimum 1% by mass of aggregate, is added to the mix in conjunction with the bitumen emulsion or foamed bitumen. This results in improved the early strength and retained strength under saturated conditions. It also assists in dispersing the bitumen throughout the mixture.

The behaviour of BSM is similar to that of unbound granular materials. BSM show a stress-dependent mechanical behaviour and a subsequent primary failure mode of permanent deformation or shear stress. However, BSM acquires flexural strength as a result of the combined effect of the dispersed bitumen and a high cohesive strength that allows the material to sustain a higher stiffness under load than the unbound aggregate. Also BSM is not prone to cracking when subjected to tensile stresses.

With BSM, the larger aggregate particles are not fully coated with bitumen; the bitumen disperses mostly amongst the finest particles, resulting in a bitumen-rich ‘non-continuous’ mortar between the coarse particles. Since the bitumen is dispersed mostly amongst the finer aggregate particles, the fines are encapsulated and immobilised. This improves the moisture sensitivity and durability of the treated materials. Provided sufficient bitumen is applied, the tendency for the BSM to pump under loading in saturated conditions is also significantly reduced because the fines are bound.

The behaviour and stiffness of BSM varies significantly depending on the quantities of bitumen and additives used. BSM performs well when cohesive strength is optimised through compliant mix design (to determine the optimal bitumen and additive contents), whilst retaining enough flexibility so that friction resistance is still activated under load. In particular, when excessive cement is used, the materials behave more like Cement Treated Mixtures (CTM) and the benefit of adding bitumen is negligible. For this reason, cement contents that greatly exceed 1% are not recommended, and the ratio of added bitumen to added additive should always exceed one.

10.5.2 Cement Bitumen Treated Mixtures (CBTM)

CBTM utilise hydraulic and bituminous binders together as stabilising agents. This aims to ensure that the layer behaviour has both good fatigue resistance and strength and reduced cracking susceptibility. Cement is added as an active filler, usually from 1-2.5% by aggregate weight. Bitumen is added as foam or emulsion, usually from 2-3.5% by aggregate weight of residual bitumen. CBTM is characterised by considerably higher cohesion and stiffness properties than BSM and therefore significantly strengthens the pavement structure compared to BSM.

The mechanical behaviour of CBTM depend on the properties and the content of hydraulic and bituminous binders. For low cement and bitumen binder contents, the behaviour of CBTM is markedly stress-dependent with a predominant failure mode of permanent deformation similar to BSM.

By increasing the bitumen content, and consequently the bitumen/cement ratio, internal cohesion and temperature dependency leads the CBTM to behave like a bituminous mixture with a predominant failure mode of fatigue. Using a higher cement content, and consequently a low bitumen/cement ratio, produces a CBTM with a higher stiffness which is more prone to shrinkage cracking, similar to a traditional cement bound granular material.

Due to the presence of hydraulic and bituminous binders, temperature has a critical influence on CBTM. Higher temperatures during curing can result in higher rates of curing and higher maximum stiffness values.

Elevated temperatures also promote higher maximum stiffness values from the production of strong bonds from cement hydration whilst also receiving stiffness contribution from the residual internal friction between aggregate particles. This suggests that CBTM suffers less distortion and rutting during hot weather compared to bituminous mixtures.

10.5.3 Cement Treated Mixtures (CTM)

CTM are produced when cement is the only binding agent used to produce the LEBM. Cement is added as an active filler, usually from 2-3.5% by aggregate weight. The mixture is similar to properties and characteristics of conventional cement bound granular material.

CTM increase the stiffness of the aggregate, significantly strengthening the pavement structure and increasing its bearing capacity. For coarse graded aggregate with a low plasticity index, cement treatment increases the strength, cohesion and durability of the mixture. The process also protects against frost and thaw cycles. However, premature cracking is a typical failure mechanism.

10.5.4 Cold Asphalt Mixtures (CAM)

CAM are produced using a high bitumen content (minimum 3%, nominal 4%) and a limited cement addition (generally no more than 2%). Although CAM are significantly different from traditional bituminous mixtures, their mechanical behaviour can be analysed following similar approaches. CAM are generally best suited for base or binder courses and, after curing, show behaviour similar to bituminous mixtures.

10.6 Performance and Durability

There has been good experience with LEBM materials elsewhere in the world, notably in South Africa. However recent experience using on LEBM for recent projects in Ireland has also been favourable. Providing the LEBM courses are designed in accordance with TII Publications (Standards)and constructed in accordance with CC-SPW-00900, the residual life of a pavement incorporating LEBM layers will be comparable to similar fully bituminous pavements.

The primary mode of failures of LEBM is permanent deformation which can be due to the following factors:

a) **Poorly graded or non-durable source of material**: This can arise due to poor design, failure of the existing pavement to break down properly during milling operations or poor quality existing pavement materials which might be water soluble or contain excessive amounts of organic materials.

b) **Excessive amount of filler**: This will cause the pavement to become brittle and will be associated with deformation and cracking. This will result in less cracking but those which do form will be larger leading to a risk of crack propagation through the overlying material.

c) **Moisture susceptibility**: Damage may be caused by traffic resulting in exposure of a LEBM to high moisture contents and pore-pressures. This results in loss of adhesion between the bitumen and the aggregate. This can be reduced by increased bitumen content, compaction and a smooth grading.

d) **Poorly formed construction joints**: Feathered or sloping joints can lead to “blow up” of the joint due to the contraction and expansion forces within the pavement.

11. Geotextiles and Geotextile Related Products and Materials

11.1 Introduction

Cracking is a major failure mechanism of asphalt pavements. One potential method of delaying the effects of cracking is the application of geotextiles and geotextile related-products within the pavement structure. Although such materials have been used in specific situations in Ireland and are more widely used elsewhere in Europe, due to differing construction techniques, materials and traffic loading, their more general applicability to the Irish road network is uncertain.

A major objective of this Chapter is to familiarise the reader with procedures for the use of geotextiles and geotextile-related products, to encourage their use and enable evidence to be gathered on their performance, thus facilitating a refinement of guidance and specification documents in the future. Further useful reading can be found in TRL 657, Road Note 41 and the RSTA Code of Practice for Geosynthetics and Steel Meshes.

This Chapter provides guidance and advice on the use of geotextiles and geotextile-related products in asphalt pavements. Specifically, it sets out the requirements and process to be followed for their use, as part of a maintenance treatment for cracks and associated defects in flexible pavements, or in new construction. However, failures and degradation resulting from the following circumstances are not addressed:

a) Asphalt deterioration.

b) Subgrade failure and associated rutting.

c) Asphalt rutting associated with permanent asphalt strain.

This Chapter does not describe the use of geotextiles that are used to separate the road foundation from the subgrade or the use of geotextiles for drainage purposes.

It should be noted that there is no conclusive evidence to date that geotextiles and geotextile-related products are cost-effective in controlling reflection cracking on roads typically in service on the road network. These products have been used for pavements over bog ramparts and overlaying concrete slabs where they may reduce cracking of the pavement. The additional cost of using geotextiles should always be considered against the use of other options including increased thickness of bituminous material to address reflection cracking in existing pavements.

11.2 Design

The assessment and suitability of use of geotextiles and geotextile-related products are set out in DN-PAV-03074.

As with all processes, the advice in this Chapter cannot cover all contingencies and it is appropriate to get advice from practitioners when sourcing these treatments as to details of a particular process and its suitability for a particular site.

11.3 Specification

Works using geotextiles and geotextile-related products shall in accordance with CC-SPW-00900.

11.4 Cracking in Asphalt Pavements

Bituminous bound layers crack in situ because of their inability to withstand strain, shear and tensile stresses created by a number of factors, typically described in the following generic terms:

a) Reflective cracking.

b) Fatigue cracking.

c) Cracking resulting from differential settlement (often prevalent in road widening schemes).

d) Thermal cracking.

The type of damage mechanism causing the cracks to appear at the pavement surface depends on the following factors:

Properties and nature of the pavement structure.

Thickness, stiffness and severity of cracking in the existing pavement.

a) Properties of the underlying soil.

b) Traffic characteristics.

c) Climatic conditions.

d) Type of construction – particularly where it is new construction or maintenance in the form of relatively thin asphalt overlays.

A wide range of possible solutions (or combinations of solutions) for cracking exist. These include:

a) Application of a geotextile for stress absorption or reinforcement.

b) Crack and seating of an existing concrete pavement.

c) Local cold milling, reinstatement and overlay.

d) Application of thick asphalt overlays.

e) Use of modified asphalt mixtures (e.g., with high bitumen content, polymer modified bitumen or designed in such a way that a porous nature is created).

11.5 Properties of Geotextiles and Geotextile Related Products

Some products interact with the bitumen bound layer to add tensile stiffness, limiting asphalt strains and reducing the development of cracking. Products for structural use may also reduce surface rutting associated with low stiffness mixes, subject to slow heavy wheel loading at high temperatures.

The following types of geotextiles and geotextile-related products are permitted for use on the National Road network.

a) Steel Mesh Products.

b) Geogrid Products.

c) Geocomposites.

Further classification of these products are provided in CC-SPW-00900.

Particular benefits claimed for specific geotextile and geotextile-related products include the following:

a) **Reinforcement at low strain –** the ability of the material to bind the asphalt layer together to resist crack propagation in either direction, spanning the potential crack.

b) **Sealing** - prevention of water penetration into lower layers and the avoidance of associated problems due to freeze/thaw effects and the need for lower drainage to remove subsurface water.

c) **Stress absorption** – the ability of the material to absorb transient stress in all directions.

Correct installation of these materials is critical to ensuring that they perform in the required manner. The methods of manufacture, installation techniques and applications for such products have undergone significant changes over time. With an ever increasing number of proprietary products, installers and potential applications, it is important to ensure that, where such materials are being considered, the product and its installation meet the requirements of CC-SPW-00900, DN-PAV-03074 and any manufacturer requirements.

11.6 Performance and Durability

There is insufficient evidence at present to prove the long term durability and overall economic benefit of these methods on the National Road network. It is acknowledged that in some very difficult sites such as bog ramparts there is anecdotal evidence that suggests a benefit from their use. Consequently, it is recommended that sites where an integral comparative section can be achieved should be identified for detailed study to improve the understanding of the products benefits.

12. Retexturing of Bituminous Pavements

12.1 Introduction

Retexturing is the mechanical reworking of a sound road surface to restore either skidding resistance, texture depth or both. Retexturing will often be carried out to comply with the skid resistance requirements of AM-PAV-06045 with the objective of restoring adequate levels of microtexture and/or macrotexture to the road surface.

A number of retexturing techniques are identified in CC-SPW-00900. These techniques are as follows:

a) Bush hammering.

b) Shot blasting.

c) Grooving/grinding.

d) Longitudinal scabbling.

e) Water jetting.

A detailed review and further guidance on the retexturing of bituminous pavements is presented in the Road Surface Treatments Association Code of Practice for Re-Texturing.

12.2 Design

Guidance on the assessment and suitability of retexturing of bituminous pavements is provided in DN-PAV-03074.

As with all processes, the advice in this Chapter cannot cover all contingencies and it is appropriate to get advice from practitioners when sourcing these treatments as to details of a particular process and its suitability for a particular site.

12.3 Specification

The retexturing of bituminous pavements shall be in accordance with CC-SPW-00900. Reference should also be made to the requirement for a prTAIT as set out in DN-PAV-03075.

12.4 Retexturing Techniques

It is essential to choose the correct retexturing treatment when planning to restore surface characteristics to ensure that the existing surface can be treated and that the required level of skid resistance can be restored for the required length of time. Should the right technique be chosen, it is likely that the process can be undertaken again at the same location and on the same surface.

It is important to note that retexturing will not cure any underlying problems within the pavement structure and in these circumstances it should be regarded as a temporary holding measure until a permanent solution can be undertaken.

Whilst process specific specifications are usually available, it must be remembered that the resulting treatment can only be as good as the surface that is being treated.

The treatments will generally increase the microtexture and macrotexture of the pavement but will not improve the condition of the surface course itself. Where the aggregate in the existing surfacing is not capable of resisting the polishing action experienced at that site then the restoration of skid resistance will only be temporary.

Treatments that remove surface matrix must be used with caution, particularly on ageing surfaces, to ensure aggregate support is not removed. Treatments that impact the surface must similarly be well controlled as too great an impact pressure will potentially dislodge surface aggregate.

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 while others may increase skidding resistance but reduce texture depth. There are also treatments which increase texture depth with little effect on skidding resistance.

Advantages may 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 the 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 short term measure which can be quickly implemented.

Disadvantages may include:

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

b) Some processes cannot treat roads with severe transverse deformation, such as heavily rutted surfaces.

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

The durability of a treatment will depend on the type and geometry of road, the quantity and behaviour of the traffic and the type and size of aggregates in the existing surface course. However, just as a new surfacing will polish under the action of traffic, the aggregate on a retextured 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, in a low stress site, the same treatment may continue to show an improvement over the untreated surface for three years or more.

The following sections give some comments on available methods and suggestions on their application for restoring skidding resistance and/or surface texture depth. Requirements on the selection of the appropriate retexturing treatment is given in CC-SPW-00900.

12.5 Impact Methods

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 and mainly affects the aggregate particles and the weathered asphaltic matrix.

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, but can sometimes reduce texture depth, depending on the condition of the existing road surface and the severity of the treatment.

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 both skidding resistance and surface texture depth of chipped rolled asphalt surfacings by removing the weathered asphaltic matrix and leaving the chippings (with renewed faces) exposed. There is a risk of chippings that are not properly embedded, such as in surface dressing, becoming loosened by this process, as the supporting matrix is removed.

12.6 Grooving/Grinding and Longitudinal Scabbling

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. The treatment affects macrotexture and can reduce texture if the blades are in a close-spaced configuration. Grooving does not improve the microtexture of the surface as the tyres are resting on the original surface which remains between the grooves.

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 to expose new aggregate faces, but it reduces surface texture depth by the same process.

12.7 Water Jetting

This involves the surface being subjected to the action of water at high temperature or pressure. These treatments do not mechanically rework the road surface to expose new aggregate surfaces, and, as a result, do not restore skidding resistance lost through the polishing action of traffic.

12.8 Other Considerations

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 surfacings than others. For example, an aggressive cutting or flailing technique would be inappropriate for a surface dressing or other surfacing type where small aggregate particles are relatively loosely bound to the substrate or surrounding matrix.

   There would be a risk of the surfacing becoming separated from the substrate by direct action of the treatment of water ingress and frost action.

b) The effect of an individual process of 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 surfacings that are generally sound. If some sealing action is required in addition to improved skidding resistance or texture, retexturing would be inappropriate. Similarly, a surface which is fretting or losing chippings may be damaged further by mechanical action.

13. Permanent Repair Material Systems and Localised Surface Repair Systems

13.1 Introduction

Permanent Repair Material Systems (PRMS) utilise a cold-lay bituminous material which shall be used for the permanent repair of surface defects, filling of road stud cavities and core holes, filling around ironworks, and utility cuttings/openings conforming to the requirements of CC-SPW-00900.

Localised Surface Repair Systems (LSRS) utilise an infra-red process that reconstitutes the surfacing material in-situ to provide a permanent repair and which conforms to the requirements of CC-SPW-00900.

13.2 Design

Guidance on the assessment and suitability use of PRMS and LSRS is provided in DN-PAV-03074.

13.3 Specification

Works using PRMS and LSRS shall be in accordance with CC-SPW-00900. Any PRMS/LSRS proposed for use shall require the prior approval of TII following the prTAIT process as outlined in DN-PAV-03075.

13.4 Properties

Surface defect repairs that may be appropriate for remedial treatment include potholes, delamination, surface cracks, joint failures and previously patched areas.

All sites with such surface defects should be considered suitable for treatment with PRMS/LSRS. However, these systems should not be seen as a long-term alternative to rectifying defects and they shall be used as part of routine maintenance works only.

14. Emergency Repair Material Systems

14.1 Introduction

Emergency Repair Material Systems (ERMS) utilise a cold-lay bituminous material which shall be used for the emergency/temporary patching and repair of surface defects, filling of road stud cavities, filling around ironworks, and utility cuttings/openings conforming to the requirements of CC-SPW-00900. Patching shall be defined as replacement of surface course, binder course and base where the materials are installed in small areas.

Surface defect repairs that may be appropriate for remedial treatment with ERMS include potholes, delamination, surface cracks, joint failures and previously patched areas.

All sites with such surface defects should be considered suitable for treatment with ERMS. However, ERMS shall only be seen as a short-term alternative to rectifying defects and they shall be used as part of routine maintenance works only.

Replacement of ERMS works shall be carried out as soon as practicably possible after installation. This work involves full-scale rectification in accordance with CC-SPW-00700, and replacement with an approved surface course in accordance with DN-PAV-03023.

15. References

15.1 TII Publication (Standards)

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AM-STR-06049 (NRA HD 30): Pavement Asset Repair and Renewal – Scheme Approval Procedures.

AM-PAV-06050 (NRA HD 31): Pavement Assessment, Repair and Renewal Principles.

CC-GSW-00700 (NRA NG Series 700): Notes for Guidance on the Specification for Road Works, Series NG 700: Road Pavements – General.

CC-SPW-00800 (NRA Series 800): Specification for Road Works Series 800 - Road Pavements - Unbound and Cement Bound Mixtures

CC-SPW-00900 (NRA Series 900): Specification for Road Works, Series 900: Road Pavements – Bituminous Materials.

DN-PAV-03023 (NRA HD 36): Surfacing Materials for New Construction and Maintenance.

DN-PAV-03074 (NRA HD 300): Design of Bituminous Mixtures, Surface Treatments, and Miscellaneous Products and Processes.

DN-PAV-03075 (NRA HD 301): Approval of Specific Products.

15.2 Other TII Publications

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15.3 Other documents

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Annex A:

Sample Road Hardness Data Collection Form

Sample Road Hardness Data Collection Form

Assessment of Road Hardness

Local Authority:			**Operator:**		
Date:			**Air Temperature (°C):**		
Chip Size (mm):			**Road Gradient:**	Relatively Flat	
Device Used:	Ball Penetration to AG:PT/T251			Steep Uphill	
	CTRA Probe to BS812: Part 112			Steep Downhill	

***Surface Condition:** Homogeneous/Normal, Ravelled/Coarse-textured or Fatted Up/Fine-textured.

Road No.	Location	Chainage	Surface Type	Surface Condition *	Surface Temp (°C)	Initial Distance (mm)	Final Distance (mm)	Comments

Annex B:

Example Recipe Surface Dressing Design Report and Checklist

Example Recipe Surface Dressing Design Report and Checklist

Route No.			
Site Category (as per Table 4.1 DN-PAV-03023)			
Site Description (as per Table 4.1 DN-PAV-03023)			
Recipe Surface Dressing Design Report Elements Considered (See Chapter 4 of DN-PAV-03074 for further details)	**Please indicate if the elements were assessed:**	**Provide a Brief Description for each element below.**	**Brief Description of Works Proposed.**
Need, objectives, constraints and options considered for the Scheme?	Yes, visual assessment of surface carried out. Ravelling of existing surface dressing recorded, improvement of SCRIM value needed	Yes, Double Surface Dressing	Double Surface Dressing Chip sizes: … Chip ROS range: … Binder Type: … Binder ROS: …
Collision History and Record	Yes, previous collisions on bend. SCRIM results below IL	N/A	N/A
Design Speed Calculations (as per DN-GEO-03031)	Yes, 70km/hr	N/A	N/A
Design Traffic (as per PE-SMG-02002)	Yes, 420 cv/lane/day	N/A	N/A
Constraints Identified?	Yes	Watermain and overhead lines identified in soft verge	Services to be protected during works
Geometric features	Yes	Existing 5% gradient with bend radius < 250m in middle of proposed works area	Maintain existing profile
Drainage Considered?	Yes	Drainage ditch provided on road edge.	N/A
Traffic Signage and Road Markings?	Yes	Existing centre line between lanes and edge marking	Maintain existing with addition of continuous white line noted below
Junction treatment	Yes	1 junction and 2 accesses – visibility below standard SSD. Constrained by existing houses.	Continuous white line
NMUs considered?	No	N/A	N/A

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Head of Road Design Section

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Ionad Ghnó Gheata na Páirce,
Stráid Gheata na Páirce,
Baile Átha Cliath 8, D08 DK10, Éire

www.tii.ie

+353 (01) 646 3600

Parkgate Business Centre,
Parkgate Street,
Dublin 8, D08 DK10, Ireland

info@tii.ie

+353 (01) 646 3601