VOLUME 6 ROAD GEOMETRY
SECTION 3

PART 4

TA 81/99

COLOURED SURFACING IN ROAD LAYOUT (EXCLUDING TRAFFIC CALMING)

SUMMARY

This advice note identifies potential applications of coloured surfacing on trunk roads to improve safety or operation. Guidance on the choice of colour and specification of materials is also provided.

INSTRUCTIONS FOR USE

1. This is a new document to be incorporated into the manual.

2. Insert TA 81/99 into Volume 6, Section 3, Part 4.

3. Archive this sheet as appropriate.

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

THE HIGHWAYS AGENCY

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

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THE DEPARTMENT OF THE ENVIRONMENT FOR
NORTHERN IRELAND

Coloured Surfacing in Road Layout (Excluding Traffic Calming)

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Contents

Chapter

1. INTRODUCTION

General

1.1 In the past, road surfaces have generally been of different shades of grey, depending upon the aggregate and binder used. New materials have recently allowed different coloured surfaces to be achieved, and the introduction of thin surfacing allows colour to be applied to existing surfaces. With these innovations, it is now possible to make use of surface colour to improve the operation of roads leading to greater safety.

1.2 This document gives advice based upon early experience of coloured surfacing on major roads **[See Annex 2]**. Where coloured surfaces are required, a co-ordinated and consistent use of colour is recommended to enhance the message of traffic signs and road markings and improve the potential benefits.

1.3 Coloured surfaces are not considered as signs or road markings and therefore have no legal status. They are intended to supplement the prescribed signs and road markings **[See Paragraph 2.11]**.

Scope

1.4 This Advice Note identifies potential applications of coloured surfacing on existing trunk roads. In the case of new roads it should not generally be necessary to employ coloured surfacing, although it may be considered at locations where relaxations within, or departures from standard have been incorporated.

1.5 This Advice Note does not provide guidance on Traffic Calming or Traffic Management schemes. Coloured surfacing has been used in association with traffic calming practices for a number of years. The Department of the Environment, Transport and the Regions (DETR) publication list identifies recent developments regarding policy on traffic control and management issues. Designers should refer to the appropriate **Traffic Advisory Leaflets** contained in the DETR publication list for current advice, applicable in England, Wales and Scotland.

Implementation

1.6 This Advice Note should be used forthwith on all schemes for the improvement and maintenance of trunk roads currently being prepared, provided that in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress.

2. DESIGN PRINCIPLES

Benefits from Using Coloured Surfacing

2.1 The evidence from schemes where coloured surfacing has been used, indicates that the effect of colour may benefit other measures implemented to improve safety or operation. Indications from a limited sample of sites, where coloured surfacing has been used in association with road signs/markings on non-trunk roads suggest that coloured surfacing has contributed to a reduction in vehicle speeds.

2.2 Coloured surfaces are almost always used in combination with road signs/markings. At junction improvement schemes and on links which have a particularly poor accident record, coloured surfacing has been shown to yield a high accident saving when it is used in combination with other measures. **(See Annex 2)**

2.3 Benefits associated with using red surfacing on areas adjacent to the running surface are harder to identify. Potential over-running is often a perceived problem and the use of coloured surfacing may be difficult to justify in terms of actual savings in accidents or improved operation.

Commonly Used Colours

2.4 The consistent use of particular colours for similar situations would be beneficial. However it is recognised that agreement concerning colour systems would be difficult to achieve between all highway authorities. Nevertheless some of the colours which have been commonly used to date are detailed below.

2.5 **Red** is commonly used to supplement prescribed markings to discourage vehicles from encroaching on an area of the road **[See Paragraphs 2.15 & 2.16]**. Other situations where red may be used (other than in traffic calming measures) are:

- Route action treatment;
- An individual accident remedial scheme;
- Locations where other colours have not been used in association with signs or road markings in the vicinity.

2.6 **Green** or red is commonly used to supplement prescribed signs/ markings to highlight an area of the road for use by buses or cycles **[See Paragraphs 2.17 & 2.18]**. However if coloured surfacing has already been applied in the locality, special care should be taken to minimise conflict.

2.7 The term **Light Colour,** for the purpose of this Advice Note, is used to represent muted or natural buff aggregate colours. The light colour is generally a by-product of the natural aggregate colour, where high friction surfacing has been applied to carriageways on the approach to a change in the road layout **[See Paragraphs 2.19 & 2.20]**.

Colour Limitations

2.8 Experience has shown that coloured surfacing is subject to fading or discoloration particularly in heavily trafficked locations and that the scheme benefits may diminish after the first 6 to 12 months. Other potential problems include the difficulty in matching the colour when reinstatement is carried out after trenching works.

2.9 Colour does not show up well on a wet road or at night under headlights or low-pressure sodium street lighting. Its performance under night-time driving conditions can be improved if combined with selective road lighting measures.

2.10 Some 5% to 9% of the driving population in the UK suffer from poor interpretation of colour. Consequently the improved contrast between road markings and the coloured surface may not be of significant benefit for this group of road user.

Purpose of Coloured Surfacing

2.11 The purpose of coloured surfacing, as indicated in **Table 2/1**, is to supplement the prescribed signs/ markings: to improve contrast of road markings and discourage vehicles from encroaching on an area of the road **[See Plates 1 to 6],** or to highlight an area of the road intended for buses and cycles. **[See Plates 7 to 9]**.

2.12 As part of a route strategy, co-ordinated and consistent colours are recommended to increase clarity, thereby improving the potential benefits of the scheme. The application of many colours at individual locations may not be environmentally acceptable and may reduce the overall impact of the safety measure.

2.13 If the coloured surfacing is in an area where

drivers may need to brake, it may need to incorporate high skid resistance properties **[See Annex 1]**.

2.14 The main categories identified in **Table 2/1** are described below together with a summary of the benefits that might be expected. The categories are based on experience and comprise applications to improve operation or where benefits from accident savings are most likely to accrue from the scheme.

To Improve Contrast Of Road Markings To Discourage All Vehicles From Encroaching On An Area Of The Road

2.15 Coloured surfacing may be used in situations where the main purpose of the colour is to emphasise the message of the prescribed markings to discourage all vehicles from encroaching on an area of the road, except in exceptional circumstances (e.g. emergencies or passing broken down vehicles).

2.16 In this context, the colour should increase driver awareness and encourage caution by highlighting the area of road excluded. Examples of its use in these situations include:

- To denote changes in the road cross-section (e.g. where a dual carriageway is reduced to a single carriageway) **[See Plate 1]**;
- On the approach to a junction where conflicts between overtaking, through and right-turning vehicles have given rise to an accident problem **[See Plate 2]**;
- To emphasise hatch markings along the centre of the road, where overtaking accidents are a particular problem. **[See Plate 3]**;
- A limited application on non-standard hard-shoulders and central reserves on motorways. **[See Plate 4]**;
- On hard areas adjacent to the running surface to deter over-running **[See Plate 4]**;
- To emphasise hatch markings on a segregated left turn lane or a subsidiary deflector island at a roundabout **[See Plate 5]**;
- At side road junctions (e.g. ghost islands) to encourage correct positioning of cars turning into the main carriageway, or at ghost islands which exclude areas of the road but may accommodate long lorries, where the road at the junction is of sufficient width. **[See Plate 6]**.

To Supplement Road Markings To Highlight An Area Of The Road Intended For Buses And Cycles

2.17 Traffic may be segregated, where regulations permit, into separate movements by vehicle classes as in cycle and bus lanes **[See Plates 7 to 9]**. In these situations colour may be used to clearly indicate the area of road used for the particular purpose, reinforcing the message of traffic signs and markings.

2.18 Where coloured surfacings are used to define a bus or cycle lane it may be appropriate to limit the extent to avoid a conflict with markings for other traffic or turning movements and where environmental effects or maintenance implications impose further constraints. In such circumstances its use, may be limited to the initial length of the lane or repeated at intervals throughout the lane, provided that the non-use of colour does not lead to confusion about the extent of the lane.

PURPOSE	MEASURES USING EXISTING STANDARDS	COMPLEMENTARY MEASURES	EXAMPLES OF USE
TO IMPROVE CONTRAST OF ROAD MARKINGS TO DISCOURAGE ALL VEHICLES FROM ENCROACHING ON AN AREA OF THE ROAD	Hatching, white	Coloured Areas Under Hatch Marking	At Road Centre-Line Under Ladder Markings
			At Segregated Left Turn Lanes and Subsidary Deflector Islands at Roundabouts
			On Junction Approaches
			On Ghost Island for Right Turners
			At change in cross-section
			At long sections of Sub-Standard Visibility
			In Island Area of Priority Junction Bellmouth
	Studs and white Edge Lines	Coloured Strip	Along Margins to deter over-running
TO SUPPLEMENT ROAD MARKINGS TO HIGHLIGHT AN AREA OF THE ROAD INTENDED FOR BUSES AND CYCLES	Signs and Road Markings	Coloured Lane	Bus and Cycle Lanes

Table 2/1: Use of Coloured Surfacing in Road Layout

To Improve Safety on the Approach to a Change in Road Layout

2.19 High friction surfacing has been applied to carriageways on the approach to bends, roundabouts, signal controlled junctions or pedestrian crossings **[See Table 2/2]**. Although this is often of a **Light Colour,** as a by-product of the natural aggregate colour **[See Paragraph A1.15]**, its primary purpose is to reduce the risk of skidding. However, in these situations it can also highlight the change in the road layout **[See Plate 10]** and improve safety, for example:

- On a high speed road in advance of a minor side road junction where accidents involving overtaking and right turning vehicles are a problem;
- On the minor road approach to a junction where high approach speeds or reduced visibility increase the risk of vehicles over-shooting the junction.

2.20 HD36 (DMRB 7.5.1) is used to determine the need for high friction surfacing on the carriageway approaches to a junction. Its purpose is to improve safety, it is not intended to replace existing junction information, advance direction or warning signs **[See Table 2/2].**

PURPOSE	MEASURES USING EXISTING STANDARDS	COMPLEMENTARY MEASURES	EXAMPLES OF USE
TO IMPROVE SAFETY ON THE APPROACH TO A CHANGE IN ROAD LAYOUT	Directional Sign	High Friction Surfacing	Approaches to Roundabouts
	Junction Warning Sign		Main Road Approach through Priority Junction
			Minor Road Approach to Priority Junction
	Bend Warning Signs		Around Bends

Table 2/2: Use of High Friction Surfacing in Road Layout

Plate 1 Coloured Surfacing used to Improve Contrast at Change in Cross Section (Dual to Single)

Plate 2 Coloured Surfacing used to Improve Contrast on a Mainline Junction Approach

Plate 3 Coloured Surfacing used to Improve Contrast Along Sections of Sub-Standard Visibility

Plate 4 Coloured Surfacing used to Improve Contrast Along Margins to Deter Over-Running

Plate 5 Coloured Surfacing used to Improve Contrast on a Segregated Left Turn Lane at a Roundabout

Plate 6 Coloured Surfacing used to Improve Contrast in the Island Area of Priority Junction

Plate 7 Coloured Surfacing used to Supplement Road Markings on a "Contraflow" Bus and Cycle Lane

Plate 8 Coloured Surfacing used to Supplement Road Markings for a Cycle Lane

Plate 9 Coloured Surfacing used to Supplement Road Markings for a Cycle Lane

Plate 10 Coloured Surfacing highlighting a change in the road layout, a by-product of High Skid Resistance Surfacing applied at a junction to reduce the risk of skidding.

3. DESIGN PROCEDURES

Introduction

3.1 The design procedure for the use of coloured surfacing in road layouts has three distinct stages:

- Scheme assessment: identification of the need and consideration of the effects of coloured surfacing leading to colour selection;
- Assessment of existing pavement condition and surface texture requirements, leading to choice of materials and method of application;
- Detailed design considerations.

Identify Need for Coloured Surfacing

3.2 The procedures to identify the need for coloured surfacing, leading to selection of colour are given in the flow chart at **Figure 3/1**.

3.3 Having identified a safety or operational problem, the first course of action should be to investigate the existing signs and road markings **[See DMRB Volume 8, Traffic Signs and Lighting]** to ensure that they are:

- Appropriate;
- In good condition;
- Of the appropriate size;
- Adequate in terms of retro-reflective performance;
- Not obscured by vegetation.

3.4 If the existing signs or road markings do not meet these requirements upgrading them in accordance with **Chapters 4 and 5 of the Traffic Signs Manual** should be carried out before considering colour to enhance the message they convey.

3.5 Alternative traffic management and/or layout solutions might be considered necessary before considering the application of coloured surfacing.

3.6 Coloured surfacing should be used selectively and only considered in situations where additional benefit can be achieved through its use. This is most likely where coloured surfacing together with standard signing is used to solve a particular accident problem, or where other alternatives have failed.

3.7 The relationship between coloured surfacing and signing and road markings will need to be considered as part of any review of overall effectiveness.

Environmental Considerations

3.8 The choice of colour should be made with regard to wider environmental considerations. A process of consultation may be desirable prior to scheme finalisation to ensure that the relevant authorities and other interested bodies have the opportunity to comment on the proposals.

3.9 In rural areas the prevailing colours are the natural greens and browns of vegetation and soil together with the grey of the road surface. In these areas red and light colours provide the best contrast, although the impact of bright colour can be intrusive and detrimental to the surrounding landscape. A balance between the benefits and aesthetics should be considered.

3.10 In urban areas there are more natural colour variations due to the effect of building materials and lighting. These will vary depending on the location and part of the country. Again a balance between the benefits and aesthetics should be considered.

3.11 Standard white road markings will generally be used in combination with the coloured surface and it is important that the overall visual effect should be considered.

3.12 Coloured surfaces may have different noise characteristics from adjacent surfaces. Therefore in considering their use near residential properties, the possibility of noise nuisance should be taken into account.

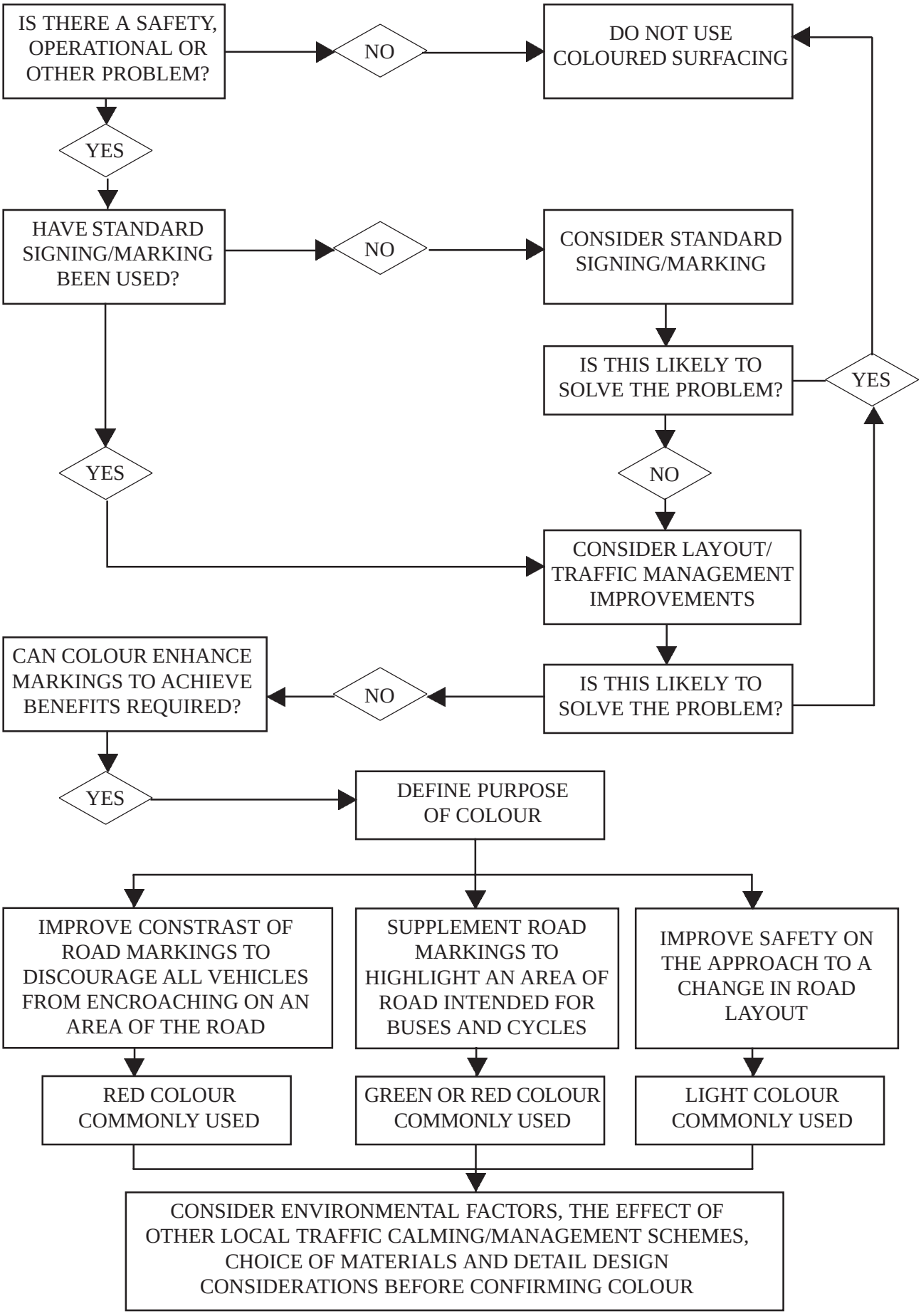

Figure 3/1: Identification of Need Leading to Use and Selection of Colour

Colour Selection

3.13 Having established that coloured surfacing may achieve an additional benefit to the scheme, the colour can then be selected on the basis of its purpose **[See Paragraph 2.11 to 2.20]**. The chosen colour should provide an effective contrast with the adjoining surface.

3.14 Commonly used colours are identified in **Chapter 2** and these are recommended for use in situations where colour is being considered as part of a new safety scheme, not necessarily for an existing one. Designers may use alternative colours where appropriate for other reasons such as environmental considerations.

3.15 In urban or residential areas (including rural villages), the use of other colours may be dictated by the presence of existing traffic management or traffic calming schemes (for better co-ordination and to avoid confusion). Advice on traffic management and traffic calming can be found in the appropriate **Traffic Advisory Leaflets**.

Existing Pavement Condition Assessment

3.16 The condition of the existing pavement should be assessed in accordance with **DMRB 7** to ensure that it is in a sound condition before the application of a coloured surfacing. The condition of the existing pavement may dictate the method of achieving a coloured surface.

Skid Resistance and Surface Texture Requirements

3.17 The selection of a material for the coloured surfacing will need to take account of the amount of wear it is expected to receive and the purpose for which it is intended.

3.18 Material selection is primarily dependent upon whether the site has high or normal skid resistance requirements.

3.19 The requirements for skid resistance and texture depth apply to coloured surface as much as to any road surface. Skid resistance requirements are described in **DMRB 7.5.1,** whilst the texture depth requirements for high-speed roads are detailed in **Series 900 of the Specification (MCHW1)**. British standards **BS 434, Part 1** (Bitumen Emulsions), **BS 594** (Hot Rolled Asphalt) and **BS 4987** (Coated Macadam) may also be relevant to coloured surfaces.

Choice of Materials and Methods of Application

3.20 Having identified the need for coloured surfacing and established the overall requirements in terms of colour and surface texture requirements it is then necessary to consider the range of available materials and their characteristics **[See Annex 1]**.

3.21 There are two basic methods of achieving a coloured carriageway surface, as described at **Annex 1**:

- **Surface dressing**, by the application of a coloured material;
- **Wearing course**, with coloured aggregates, fillers or binders used in the mixture.

3.22 The colour of the surfacing may be achieved by a combination of the following, as described at **Annex 1**:

- Naturally occurring coloured aggregate;
- Colour coated aggregate;
- Coloured binder.

3.23 In selecting the most appropriate material for a particular location, the following should be considered:

- Skid Resistance;
- Durability;
- Colour Retention;
- Adhesion to existing surface (Surface dressings);
- Ride quality;
- Cost.

Detail Design Consideration

3.24 The use of coloured surfacing in a road layout should be justified in terms of safety or operational benefits. The costs of installing and maintaining a coloured surfacing will depend upon a number of factors including:

- Initial cost of materials and its application;
- Maintenance requirements;
- The type and volume of traffic on the existing road and the complexity of the road layout;
- Traffic management for the application of coloured surfacing may contribute significantly to the overall cost of the scheme in some cases.

3.25 All of these factors should be taken into account during the assessment and preparation of the scheme in accordance with The Overseeing Organisation's guidelines for scheme selection contained in **DMRB 5.**

3.26 In addition to those design criteria which lead to the choice of colour and the choice of material there are a number of associated design implications which must be addressed as part of the scheme assessment and detailed design.

Drainage Considerations

3.27 The effect on drainage paths across the carriageway needs to be considered where large areas of surface dressing are proposed. Excessive thickness should be avoided as this may trap surface water on the running surface at the edges of the area of application.

Maintenance Considerations

3.28 The maintenance cycle for surface dressing materials should be compatible with that of the applied road markings. For mixed-in wearing course materials however the design life of the road will generally exceed that of the colour life.

3.29 It is highly unlikely that the colour life of a surface will be as great as the service life. All coloured surfaces will undergo traffic and environmentally induced changes in appearance. Colour restoration techniques will only be economic if the pavement and surface have sufficient service life left (structural strength, texture depth and skid resistance) to warrant the maintenance costs.

3.30 Application of coloured surfacing to the full length of a cycle or bus lane may impose long term maintenance requirements.

3.31 During maintenance it would be beneficial to match the colour of any reinstatement with the surrounding surface. Extra effort should be taken to maintain the appearance and hence the benefit of colour.

3.32 Applied materials should be capable of being removed from the road surface using standard equipment without causing permanent damage to the carriageway, or reduction in residual life of the pavement. It may not always be possible however to remove the applied material without causing damage to the underlying road surface, therefore it will be necessary to take into acount the resurfacing costs, when considering applying coloured surfacing on a trial basis, should the applied material be removed following the trial.

4. REFERENCES

1. DESIGN MANUAL FOR ROADS AND BRIDGES (DMRB):

a. **Volume 5 -** Assessment and Preparation of Road Schemes.
b. **Volume 6 -** Road Geometry.
c. **Volume 7 -** Pavement Design and Maintenance.
d. **Volume 8 -** Traffic Signs and Lighting.

2. BRITISH STANDARDS

a. **BS 63**: Part 1:1987 - Specification for single sized aggregate for general purposes.
b. **BS 63**: Part 2:1987 - Specification for single sized aggregate for surface dressing.
c. **BS 76**: 1974 - Specification for tars for road purposes.
d. **BS 381c**: 1996 - Colours for identification, coding and spread purposes.
e. **BS 434**: Part 1:1984 - Specification for bitumen road emulsions.
f. **BS 594** - Hot rolled asphalt for road and other paved areas.
g. **BS 1014**:1975 - Pigments for Portland cement and Portland cement products.
h. **BS 1707**:1989 - Specification for hot binder distributors for road surface dressing.
i. **BS 3262**:1989 - Hot-applied thermoplastic road marking materials.
j. **BS 3690** - Bitumens for building and civil engineering Parts 1 and 3.
k. **BS 4987** - Coated macadam for roads and other paved areas.
l. **BS 5273** - Dense tar surfacing for roads and other paved areas.
m. **BS 6044** - Specification for pavement marking paints.

3. TRAFFIC SIGNS REGULATIONS

a. SI 1994 No 1519 - The Traffic Signs Regulations and General Directions 1994: Stationery Office.
b. Traffic Signs Regulations (Northern Ireland) 1997: Stationery Office.

4. TRANSPORT RESEARCH LABORATORY

a. Road Note 39, Design guide for road surface dressing, 4th edition (1996): TRL.
b. Road Note 25, Sources of white and coloured aggregates in GB, 2nd Edition (1986): TRL.
c. Road Note 36, Specification for the manufacture and use of rubberised bituminous road materials and binders, 2nd edition (1968): TRL.
d. LR 510, A guide to levels of skidding resistance for roads (1973): TRL.
e. TRL 125, Trials of high-friction surfaces for highways (1998); TRL.

5. ROAD SURFACE DRESSING ASSOCIATION

a. Code of Practice for Surface Dressing (1990): RSDA.
b. Advice Note on Surface Dressing Binders (1990): RSDA.
c. Guidance Note on Surface Dressing Aggregates (1993): RSDA.
d. Guidance Note No. 87/1, Racked-in Surface Dressing (1992): RSDA.

6. OTHER SPECIFICATIONS

a. Specification for Highway Works (1998) MCHW1: Stationery Office.
b. Highway Authorities tender specification: County Surveyors Society.

7. MISCELLANEOUS

a. Traffic Advisory Leaflets (Bibliography) available from CLT Division – DETR.
b. Fletcher R and Voke J (1985): Defective colour vision - fundamentals, diagnosis and management, Adam Hilger Ltd.: Bristol.
c. Traffic Signs Manual: Stationery Office.

5. ENQUIRIES

All technical enquiries or comments on this document should be sent in writing as appropriate to:

Traffic, Safety and Environment Divisional Director
Highways Agency
St Christopher House
Southwark Street
London
SE1 0TE

G CLARKE
Traffic, Safety and Environmental
Divisional Director

The Deputy Chief Engineer
The Scottish Office Development Department
National Roads Directorate
Victoria Quay
Edinburgh
EH6 6QQ

J HOWISON
Deputy Chief Engineer

Head of Major Roads Division
Welsh Office Highways Directorate
Cathays Park
Cardiff
CF1 3NQ

B H HAWKER
Head of Major Roads Division

Assistant Technical Director
Department of the Environment for
Northern Ireland
Roads Service Headquarters
Clarence Court
10-18 Adelaide Street
Belfast
BT2 8GB

D O'HAGAN
Assistant Technical Director

MATERIALS

General

A1.1 Coloured surfacing materials are still developing, and hence no single specification clause exists at present. This Annex to the Advice provides guidance on material specification.

A1.2 The **BBA (British Board of Agrement) HAPAS (Highways Authority Product Approval Scheme)** now includes high friction surfacing system with a comprehensive monitoring procedure for manufacture, installation and mechanical performance but does not include colour durability in its scope.

A1.3 A series of trials, on materials laid between 1991 and 1993 have been set up in the UK to compare the performance of three alternative resin systems with those of epoxy-resin systems. Laboratory tests have also been established to simulate accelerated wear under trafficking. Early results from these trials and tests are contained in the **Transport Research Laboratory Report** (TRL Report 125).

A1.4 Coloured surfacing should be resistant to de-icing salts and other chemicals used during winter maintenance. Resistance of the colour coating of the surface can be assessed using existing British Standard Salt Spray Exposure Tests **(BS 3900: Part F9)**.

Surface Dressings

A1.5 Since coloured surfacing is normally applied to existing surfaces the method most commonly used is surface dressing **HD37 (DMRB 7.5.1)**. The different methods of surface dressing and types of material are summarised in **Table A/1** and the relevant standards are contained in **Series 900 of the Specification (MCHW1)** and **BS 434**.

A1.6 Slurry material is normally used only on lightly or un-trafficked surfaces unless the particular material has been specified for heavy-duty use.

A1.7 Surface dressings may not have a very long life where heavy commercial traffic is likely to turn sharply and scour the surface.

A1.8 Surface preparation is a key factor in the performance of applied materials. Surfaces should be clear of rubber deposits, loose material and be clean and dry. Hot compressed air is commonly used for drying. If the receiving surface is badly cracked or crazed then reconstruction measures should be completed prior to surface dressing.

A1.9 Colouring of surface dressing is usually achieved using natural coloured aggregates. The full range of colours available is given in the **British Aggregate Construction Materials Industries Guide (BACMI)**, now Quarry Product Association (QPA), with sources of aggregates given in **Road Note 25**. Natural coloured-materials available include:

- Gravels in browns and buffs;
- Limestones and spars in whites and creams;
- Basalts in dark grey;
- Granites in pink, red and green.

A1.10 Chippings used for surface dressing should comply with **BS 63: Part 2**. When used as the primary layer they should have the required minimum polished stone value **(PSV)** and aggregate abrasion value **(AAV)** for the site conditions and traffic intensity. Artificial aggregate, usually ***calcined bauxite***, is generally used in resin-based high skid resistance surfaces.

A1.11 A guidance note from the **Road Surface Dressing Association (RSDA)** gives advice on the selection of PSV for aggregates used in surface dressing, which together with extracts from **LR 510** describe the selection process in relation to volumes of traffic. Only a few quarries in the UK can supply aggregates for surface dressings with a PSV of 68 or above. ***Calcined bauxite*** imported from Guyana and China can achieve PSV's of around 70 but they can be more expensive than UK aggregates.

A1.12 The size of chippings should be chosen to suit the volume of traffic and hardness of the substrate. **Road Note 39** provides guidance for selection and deals with the special case of porous surfaces. The chipping size and correct rate of spread of binder will mitigate penetration of the binder into the interstices of the surfacing.

Wearing Course

A1.13 **Table A/2** lists the methods of achieving colour in a wearing course. These are applicable in cases where the road surface is being re-constructed with a new wearing course. These methods may be used, provided they fully meet with the required standards for wearing course materials.

Primary Method	Complementary Means	Comment
1. Thin slurry seal (3mm application, no chippings) with colour pigmentation.	Coloured aggregate.	
2. Thin slurry seal with clear binder and coloured aggregate.		
3. Thick slurry seal (polymer modified bituminous emulsion with 6mm graded aggregate) with colour pigmentation.	Coloured aggregate.	
4. Thick slurry seal with clear binder and coloured aggregate.		
5. Surface dressing using naturally coloured aggregates.	Binder Pigmentation	Principle method of routine maintenance, chippings to comply with PSV and AAV requirements. Further information is contained in Road Note 39 and BS 63 part 2. Colours available are given in the British Aggregate Construction Materials Industries Guide.
6. Surface dressing, resin based high friction surface treatment.	Binder Pigmentation	Aggregate to be of high polishing resistance.

Table: A/1 Method of Achieving a Coloured Surface Dressing

Primary Method	Complementary Means	Standard	Comment
1. Colour pigment in macadam/asphalt mix.	Aggregate of complementary colour	BS 4987 BS 594	
2. Replacement of black bitument binder with coloured binder.	Aggregate of complementary colour	BS 4987 BS 594	
3. Proprietary macadam type mix, black bitumen binder replaced with clear resin.	Coloured aggregate	BS 4987	Relies on aggregate for colour.
4. Use of coloured aggregate in standard (black bitumen) mix.		BS 4987 BS 594	Colour is only apparent after traffic removes surface binder film, muted by bitumen binder.
5. Application of pigmented bitumen coating to chippings, or clear resin coating to coloured chippings embedded in wearing course.		MCHW1, Series 900 BS 594	Chippings to meet PSV requirements.
6. Colour pigment in Portland cement products in concrete surfacing.	Alternatively, special aggregates may produce whiter or coloured effect.	BS 1014 MCHW1,	Strict control necessary to provide even coloration.

Table A/2: Method of Achieving a Coloured Wearing Course

High Friction Surfacing

A1.14 Where high friction surfacing is required, neither polymer modified binders nor conventional high PSV aggregates are generally considered to be adequate. High friction surfaces usually consists of a sprayed film of a resin based or plasticised resin binder covered with aggregate of high polishing resistance usually consisting of ***calcined bauxite***. In theory, a wide range of colour coated aggregates can be used but the colour effect tends to wear off in time, revealing the colour of the base aggregate. The relative resistance of coatings to wear has been assessed using laboratory tests **[See Paragraph A1.3]**. Naturally occurring coloured aggregates are unlikely to meet the highest PSV criteria for aggregate in this particular application, although ***red quartzite*** and ***criggion basalt*** have been used.

A1.15 ***Bauxite*** aggregates are generally grey or buff in colour and are often used where high skid resistance is necessary. ***Chinese bauxite*** may give a lighter effect than some other materials.

A1.16 High friction surface treatments tend to be more expensive than surface dressings but are capable of meeting similar durability requirements in more onerous situations.

A1.17 The performance of resin based treatment on concrete may not be as good as on bituminous surfaces because of the difficulty of obtaining a good bond between the binder and the concrete over large areas. The main reason for bond failure is the different coefficients of thermal expansion for concrete and resin.

A1.18 Binder systems used for high skid resistance surfaces include:

- Epoxy resins;
- Polyurethane resins;
- Rosin esters.

A1.19 Polyurethane resins exhibit greater flexibility and adhesion than epoxy resins and do not age harden to the same extent. Nevertheless, extensive comparative trials have shown epoxy resin systems to be marginally more durable than polyurethane systems after many years of trafficking. The elastoplastic properties of polyurethane systems can be enhanced by the use of SBS rubber and acetate co-polymers.

A1.20 Polyurethane resins cure more rapidly than epoxy resins allowing earlier opening of treated sites to traffic, especially at low temperatures. The fast rate of curing is effected by the use of accelerators and depends on overall material recipe, which varies between suppliers. Some manufacturers produce a winter grade for application at temperatures below 5C. However polyurethanes are very sensitive to moisture and should not be applied to damp substrates. Both the adhesion of the resin to the substrate and the adhesion of the bauxite to resin can be reduced in damp conditions. Epoxy resins have a longer curing time at low temperatures, but can be more tolerant of damp.

A1.21 There are two main surface systems types of high skid resistance:

- **Thermoplastic** "hot applied" (materials solidify on cooling);
- **Thermosetting** "cold applied" (materials cure by chemical action).

A1.22 Hot applied thermoplastic systems are traditionally applied as a combined mass of the aggregate and the thermoplastic binding medium and can usually be trafficked after about 20 minutes, reducing lane closure times. It is often applied by hand using a suitable sized screed box.

A1.23 Cold applied thermosetting systems generally have a very high resistance to stress. They involve the mixing of two or more components prior to application, spraying or spreading by hand the resultant binder, and the broadcasting of aggregate, generally to excess, with the excess being removed after curing. The curing time, a minimum of about one hour with trafficking allowed after 2 hours, is longer than that required for hot applied thermoplastic systems. For larger contracts, continuous mixing of the binder and application by sprayer, with the aggregate applied by mechanical gritter is the most common method employed.

A1.24 Cold applied thermosetting systems are usually applicable for maximum anti-skid performance with high traffic volumes and hot applied thermoplastic systems for medium to low traffic situations. However to avoid discriminating against products that are suitable only for moderately or lightly trafficked sites, and also to encourage innovation, the BBA HAPAS certification scheme to assess high friction surfacings has been set up.

BBA HAPAS Assessment

A1.25 High friction surfacing systems are classified during the assessment into three types, as shown in Notes for Guidance, Table NG 9/15 (MCHW2). Each Type classification has an expected service life of between 5 and 10 years at the maximum traffic levels shown in Table NG 9/15 (MCHW2). Type 1 for heavily trafficked sites, Types 1 & 2 for moderately trafficked sites and Types 1, 2 & 3 are suitable for very lightly trafficked sites. A Type 1 system used on a moderately or lightly trafficked site can offer a much extended life, twenty years is not unknown. Conversely a Type 3 system used on a heavily trafficked site will have a much reduced working life. Site constraints and the time of year can favour the use of less robust systems, generally thermoplastic hot applied materials, for convenience. This is not advisable unless safety or other considerations allow no alternative. In such circumstances replacement may be necessary within two to three years.

Material Selection at Locations Requiring Normal Skid Resistance

A1.26 There are two basic types of surface systems available:

- **Screeded thermoplastic** "hot applied" surface treatment applied as a mix of plasticised resin, polymers and aggregate;
- **Screeded/sprayed thermosetting** "cold applied" resin binder combined with a broadcast/spread aggregate layer.

Binder systems used for normal skid resistance surfaces include:

- Plasticised resins;
- Acrylic resins;
- Epoxy resins;
- Polyurethane resins.

A1.27 Thermoplastic materials tend to be more brittle but retain colours for longer. Acrylic resins (thermosetting) however are generally used as they are UV stable but are only suitable for thin applications (1.5mm - 2.0mm) as they become too rigid when applied in thicker layers. Tests exist to assess the relative susceptibility of coloured materials to the action of UV exposure and artificial weathering (ASTM G53-96), noting that there are no modern British Standard Tests at present.

A1.28 As guide, colours are defined in BS 381C. Pigmentation can be achieved within the matrix, or by using a naturally coloured aggregate or a coated aggregate or a combination of either. Some resin-based products may not hold colour very well and colour changes are noticeable after 12 months. Colours fade due to exposure to UV light.

A1.29 Naturally coloured aggregates can be used in combination with a coloured binder. The amount of coloured aggregate in the material needs to be greater than 50% by mass in order to provide a long-term colour effect. Applications using colour-coated aggregates have tended to look drab soon after use as the coating wears off and the aggregates return to their natural colour.

A1.30 The aggregate size is typically in the range 1 mm - 4.75 mm, providing a 5 mm thick layer.

A1.31 The PSV of the aggregate should match or exceed the adjacent running carriageway as the coloured sections will be overrun from time to time. A difference across running lanes is permitted in **HD 36 (DMRB 7.5.1)** where aggregates are used for demarcation.

A1.32 Thermoplastic material is hot applied and traffic can be reinstated after approximately 20-30 minutes or when the surface has reached the ambient temperature. Overheating during preparation of the material can lead to colour differences between batches.

A1.33 As with high friction surface treatments, cold applied surfacing are available, and involve broadcasting of 3 - 5mm coloured aggregates to achieve a full effect. At the present time, epoxy and polyurethane based products generally last longer than thermoplastic materials when applied to areas carrying high traffic volumes.

EARLY EXPERIENCE

A2.1 It is difficult to isolate the impact of the colour from other measures when used as part of a route action plan, as scheme wide benefits may outweigh benefits from individual schemes. Red coloured surfacing has been used under central hatch markings on the A1 and other trunk routes as part of route action plans in both Scotland and England, which have led to a 40 to 50 per cent reduction in accidents.

A2.2 Examples where red coloured surfacing have been used under hatch markings on mainline junction approaches and ghost islands for right turns include:

- The A19 in North Yorkshire, as part of a comprehensive safety improvement scheme which included a small kerbed island where accidents were reduced from 21 in 36 months to 3 in 15 months;
- The A617 in Nottinghamshire where the accident rate was reduced from 3 in 12 months to 1 in 12 months;
- The A1 in the Lothian region where the accident rates on two separate schemes were reduced from 3 in 43 months to 1 in 30 months and none in 30 months respectively;
- The A31 in Hampshire where although there was insufficient width to provide ghost islands for right turning vehicles, the application of coloured surfacing beneath the central hatching reduced the accident rate from 8 in 12 months to none in 12 months;
- Two trial sites on the A17 where, although vehicle speeds were not significantly reduced, far fewer violations were made of the hatch markings after the red surfacing had been applied as part of junction treatments. This suggests that greater driver caution was being exercised through the junction as a result of the application.

A2.3 Coloured surfacing has also been used to prevent potential overtaking accidents along sections of road with poor visibility. An example is the A427 in Northamptonshire where the overtaking accidents were reduced from 6 in 3 years to none in 2 years by the application of red surfacing under central hatch markings along the link.

A2.4 On the A30 spur in Hampshire, accidents occurred due to poor visibility and high speeds on the approach to the junction, which resulted in vehicles over-running the junction. By a combination of measures including the use of extended coloured lanes on the approach to the junction accidents have been reduced from 29 in 3 years to 2 in 2 years.