
**VOLUME 7 PAVEMENT DESIGN AND
 MAINTENANCE**
SECTION 1 PREAMBLE

PART 1

HD 23/99

GENERAL INFORMATION

SUMMARY

This Part is an introduction to the whole of Volume 7. It updates and replaces HD 23/94.

INSTRUCTIONS FOR USE

1. Remove HD 23/94 which is superseded by HD 23/99 and archive as appropriate.
2. Insert HD 23/99 into Volume 7 Section 1 Part 1.
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



**THE WELSH OFFICE
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**THE DEPARTMENT OF THE ENVIRONMENT FOR
NORTHERN IRELAND**

DESIGN MANUAL FOR ROADS AND BRIDGES

Volume 7: Pavement Design and Maintenance

General Information

Summary:	This part supersedes HD 23/94
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REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

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**VOLUME 7 PAVEMENT DESIGN AND
MAINTENANCE**
SECTION 1 PREAMBLE

PART 1

HD 23/99

GENERAL INFORMATION

Contents

Chapter

1. Introduction
2. Background
3. Use of Volume 7
4. Glossary of Terms
5. Principal Abbreviations
6. Enquiries

1. INTRODUCTION

General

1.1 This Part is an introduction to the whole Volume.

1.2 Volume 7 of the DMRB consists of a series of linked documents. Table 3.1 in this Part gives a full list of the documents and a clear chart of the contents of each Part. Changes to Volume 7 are always in hand, Table 3.1 will not necessarily include all the latest amendments.

1.3 The Transport Research Laboratory (TRL), previously operated as the Transport and Road Research Laboratory (TRRL). Both abbreviations have been used in Volume 7.

1.4 Paragraphs of Volume 7 which form part of the standards that the Overseeing Organisation expects are highlighted by being contained in boxes. These are the sections with which the designer must comply. The remainder of the document contains advice and enlargement which is commended to designers for their consideration.

Implementation

1.5 This Part of Volume 7 of the Design Manual for Roads and Bridges (DMRB) is provided for general information. Each Part of Volume 7 should be consulted for the relevant Implementation Clause

1.6 The use of Volume 7 is mandatory for trunk roads including motorways. It is intended to provide more background, explanation and advice than the superseded documents. The objective is, however, to provide an instruction manual, not a full technical review or textbook. With regard to pavement assessment and maintenance, it should be read in conjunction with the Overseeing Organisation's maintenance instructions. In England and Wales, these are contained within the respective Trunk Road Maintenance Manuals

Mutual Recognition

1.7 Where Parts of Volume 7 give the Overseeing Organisation's requirements for products, they make provision for the acceptance of equivalent products from other member states of the European Community. Reference should be made to the statement in each Part concerned.

Miscellaneous

1.8 Volume 7 does not deal with seasonal or routine maintenance, safety aspects other than skidding resistance, or specialist aspects such as the surfacing of bridge decks. For advice on these aspects reference should be made to the Overseeing Organisation.

1.9 Frequent references are made to documents contained in the Manual of Contract Documents for Highway Works (MCHW) as follows:

- Specification for Highway Works (MCHW1).
- Notes for Guidance on the Specification for Highway Works (MCHW2).
- Highway Construction Details (MCHW3).

1.10 References are made in the text to other documents by author and date except for British Standards, TRL/TRRL Reports and Overseeing Organisation Publications, which are referred to by number (or name) and date. A full list of References is included in each Part.

2. BACKGROUND

2.1 Current UK practice in pavement design and maintenance has developed from a combination of practical experience, laboratory research and full-scale road trials. Most of the research has been carried out over a number of years by the Transport Research Laboratory (TRL), some with the assistance of external research contracts.

2.2 TRRL Report LR 1132 (1984) provides details of UK research findings in connection with the design and performance of flexible pavements. The report makes use of the results of full-scale road experiments and uses analytical techniques to rationalise and extend the data. Many of the recommendations have since been adopted by the Overseeing Organisations.

2.3 TRRL Report RR 87 (1987) provides comparable findings in connection with rigid pavements and many of the recommendations have also been adopted by the Overseeing Organisations.

2.4 Significant developments have also taken place in other countries, particularly in connection with the analytical or mechanistic approach to design. This is based on the traditional structural design philosophy, which requires an understanding of material behaviour under load and an appropriate theoretical analysis of the design problem.

Pavement Components

2.5 Figure 2.1 illustrates two typical cross-sections of road pavements in the U.K. The terms used, together with others used in Volume 7 are defined in Chapter 4, the Glossary of Terms.

2.6 The underlying subgrade soil (cut or fill), capping (if used) and sub-base comprises the **Foundation**, the platform upon which the more expensive and structurally significant layers are placed. This platform is designed to be of a certain minimum standard quality whatever the underlying soil condition. It is not a drainage layer although it does itself require to be adequately drained since it is never totally impermeable.

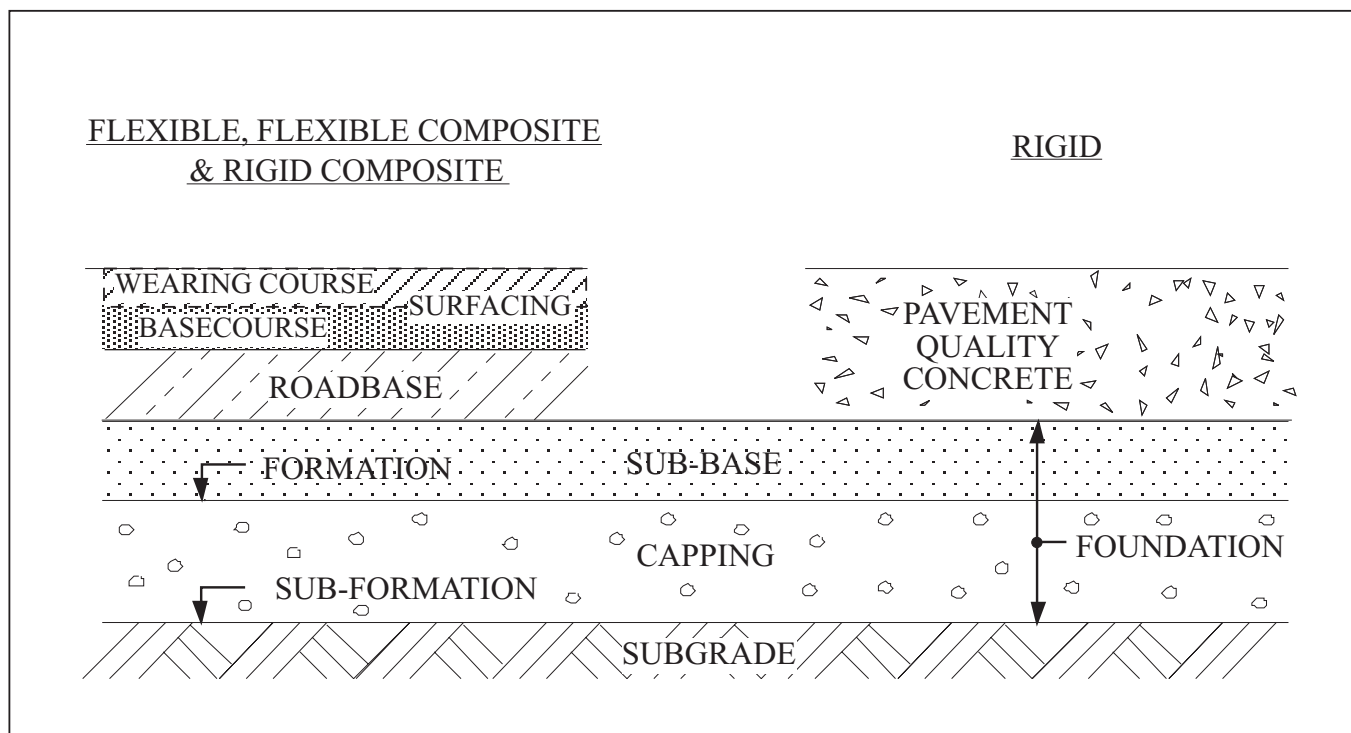


Figure 2.1 Typical Pavement

2.7 The **Roadbase** is the main structural layer of the pavement, required to distribute the applied traffic loading so that the underlying materials are not overstressed. It must be able to sustain the stresses and strains generated within itself without excessive or rapid deterioration of any kind.

2.8 The function of the **Surfacing** is to enable good ride quality to be combined with the appropriate resistance to skidding and to resist crack propagation. For this, texture and durability under traffic are required. In the case of concrete roads, the surfacing and roadbase are combined to form a single layer.

Pavement Types

2.9 Four different types of pavement are defined by the Overseeing Organisation.

a) Flexible:

The surfacing and roadbase materials are bound with bituminous binder.

b) Flexible Composite:

The surfacing and upper roadbase (if used) are bound with bituminous binder on a roadbase or lower roadbase of cement bound material.

c) Rigid:

Pavement quality concrete is used for the combined surfacing and roadbase. The concrete can be:-

Jointed unreinforced (URC)
Jointed reinforced (JRC)
Continuously reinforced (CRCP)

d) Rigid Composite:

Continuously reinforced concrete roadbase (CRCR) with bituminous surfacing.

Pavement Performance

2.10 Pavements do not fail suddenly but gradually deteriorate in serviceability to a terminal level which may be defined as failure. The rate of deterioration often accelerates as failure is approached. This is represented

by an unacceptable degree of rutting, general unevenness, cracking, crazing etc. In the case of the surfacing, loss of skid resistance can be equivalent to failure.

2.11 Some pavements, with thicker bound layers constructed on a good foundation, maintain their strength or become stronger over time, rather than gradually weakening with trafficking. Such pavements, built above a threshold strength, will have a very long structural service life, provided that distress, in the form of cracks and ruts appearing at the surface, is treated before it begins to affect the structural integrity of the road. These are referred to as *long-life* pavements.

2.12 It is good practice and the Overseeing Organisation's intention to ensure that major maintenance or strengthening of the pavement takes place at a point such that the structural contribution of the existing pavement layers is largely retained.

2.13 To monitor the performance of a pavement, the Overseeing Organisation requires the use of a number of assessment machines and methods. These include the High speed Road Monitor, the Deflectograph, FWD, SCRIM, visual condition surveys, etc. In this way the appropriate timing can be chosen for the various necessary maintenance processes which all pavements eventually require.

Maintenance

2.14 Clearly any of the three main components of a pavement (Foundation, Roadbase, Surfacing) can deteriorate, leading to a reduction in the quality of performance of the overall structure. Depending upon the mode of deterioration, deduced from the various pavement assessment processes, maintenance measures ranging from surface treatment through to total reconstruction may be necessary.

2.15 Whichever type of maintenance measure is to be adopted, it is always of the utmost importance that the correct procedures are followed to render the repair/strengthening as effective and long-lasting as possible.

3. USE OF VOLUME 7

3.1 The order of the section in Volume 7 is generally based on the life cycle of a road pavement, ie. design, construction, assessment then maintenance (see Table 3.1). This starts with consideration of the cumulative traffic loading which the pavement is required to carry, followed by the design of the foundation, the roadbase or main structural component and the surfacing. There is then a need to assess the behaviour in service and to design and carry out appropriate maintenance. It must, however, be emphasised that there is interaction between the components and that they cannot always be dealt with in isolation. The following is a brief outline of the contents of each of the sections and parts.

Section 1: Preamble

- 3.2 **Part 1** is this general introduction to Volume 7.
- 3.3 **Part 2** gives technical information on the conservation and use of reclaimed materials.

Section 2 : Pavement Design and Construction

- 3.4 **Part 1** describes the calculation of design traffic for both new roads and maintenance. It also covers the calculation of past traffic, needed in pavement assessment analysis.
- 3.5 **Part 2** gives details of the design of a pavement foundation and of tests used for the assessment of existing subgrade and sub-base materials.
- 3.6 **Part 3** covers the design of the roadbase and surfacing for new roads, including all the various types of pavement allowed.
- 3.7 **Part 4** covers particular aspects of the construction process that are relevant to this Volume but not covered elsewhere, including pavement widening and rapid concrete construction.

Section 3 : Pavement Maintenance Assessment

- 3.8 **Part 1** describes the use and interpretation of SCRIM for monitoring skidding potential.
- 3.9 **Part 2** lists the machines and methods used for the structural assessment of a pavement. It also describes the analysis and interpretation associated with each.
- 3.10 **Part 3** details the procedure to be used in structural assessment, the appropriate use of each method and the overall interpretation. The choice and design of strengthening measures is also included.

Section 4 : Pavement Maintenance Methods

- 3.11 **Part 1** gives details of the techniques for maintenance of roads containing bituminous materials, including advice on recycling.
- 3.12 **Part 2** covers the maintenance of concrete roads from surface treatments through to reconstruction.

Section 5: Surfacing and Surfacing Materials

- 3.13 **Part 1** covers the general suitability of materials for different uses and other surfacing requirements.
- 3.14 **Part 2** details the various bituminous surfacing materials and processes that are available.
- 3.15 **Part 3** details the various concrete surfacing materials and processes that are available.

Flow Charts

- 3.16 Figure 3.1 is a flowchart which is intended to show the interrelations which exist between the section and parts in Volume 7.

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1. Introduction	1. Introduction
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2. Standard Method	2. Subgrade Assessment	2. Design Implementation	2. Widening of Pavements
3. Structural Assessment & Maintenance	3. Capping and Sub-base	3. Roadbase Materials	3. Rapid Construction and Repair of Concrete Pavements
4. Lane Distribution	4. In-situ Testing	4. Surfacing Materials	4. Not currently used
5. References and Bibliography	5. References and Bibliography	5. Design Criteria	5. Not currently used
6. Enquiries	6. Enquiries	6. The Analytical Approach	6. References and Bibliography
		7. References and Bibliography	7. Enquiries
		8. Enquiries	

SECTION 3. Pavement Maintenance Assessment			
PART 1 HD 28 Skidding Resistance	PART 2 HD 29 Structural Assessment Methods	PART 3 HD 30 Structural Assessment Procedure	PART 4 HA 72 Use and Limitation of Ground Radar for Pavement Assessment
1. Introduction	1. Introduction	1. Introduction	1. Introduction
2. Not currently used	2. High Speed Road Monitor	2. Routine Structural Assessment	2. Ground Radar for Non-destructive Testing
3. Use of SCRIM	3. Visual Condition Surveys	3. Collection and Review of Existing Data	3. Use of Ground Radar
4. References and Bibliography	4. Deflection Testing	4. Planning Detailed Investigation	4. Survey Procedure
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Annex	Annex	Annex	Annex
1. Calibration	1. Deflection Beam	A. Flexible Composite Pavements and Pavement Condition Information	A. Technical Survey Brief
2. Operational Procedures	2. Deflectograph		B. Quality Control Plan
3. Use of Different Types of Test in Accident Investigation	3. Deflectograph - Analysis and Interpretation		C. Determination of Layer Thickness from a Ground Radar Waveform
	4. FWD Requirements for Consistency Check		

SECTION 4. Pavement Maintenance Methods		SECTION 5. Surfacing and Surfacing Materials		
PART 1 HD 31 Maintenance of Bituminous Roads	PART 2 HD 32 Maintenance of Concrete Roads	PART 1 HD 36 Surfacing for New and Maintenance Construction	PART 2 HD 37 Bituminous Surfacing Materials and Techniques	PART 3 HD 38 Concrete Surfacing and Material
<ol style="list-style-type: none"> 1. Introduction 2. Surface Treatments 3. Minor Maintenance 4. Major Maintenance 5. Recycling 6. In-situ hot recycling 7. References and Bibliography 8. Enquiries 	<ol style="list-style-type: none"> 1. Introduction 2. Surface Treatments 3. Joint Repairs 4. Structural Repairs 5. Strengthening 6. References and Bibliography 7. Enquiries <p>Annex</p> <ol style="list-style-type: none"> 1. Maintenance and Repair Procedures 	<ol style="list-style-type: none"> 1. Introduction 2. Surfacing Options 3. Texture and Aggregate Properties 4. Not currently used 5. Tyre/Road Surface Noise 6. References and Bibliography 7. Enquiries 	<ol style="list-style-type: none"> 1. Introduction 2. Bituminous Surfacing Materials 3. Binders and Binder Modifiers 4. Hot Rolled Asphalt 5. Porous Asphalt 6. Thin Surfacing 7. Stone Mastic Asphalt 8. Surface Dressing 9. High Friction Surfacing 10. Slurry Surfacing and Micro-surfacing 11. Retexturing (Bituminous) 12. Not currently used 13. Miscellaneous Surfacing Materials 14. References and Bibliography 15. Enquiries <p>Annex</p> <ol style="list-style-type: none"> A. Method for Determination of Loss of Chippings and Proportion of Broken Chippings 	<ol style="list-style-type: none"> 1. Introduction 2. Transverse Textured Concrete Surface 3. Exposed Aggregate Concrete Surface 4. Retexturing (Concrete) 5. Not currently used 6. References and Bibliography 7. Enquiries

TABLE 3.1 Layout of Volume 7 : Pavement Design and Maintenance

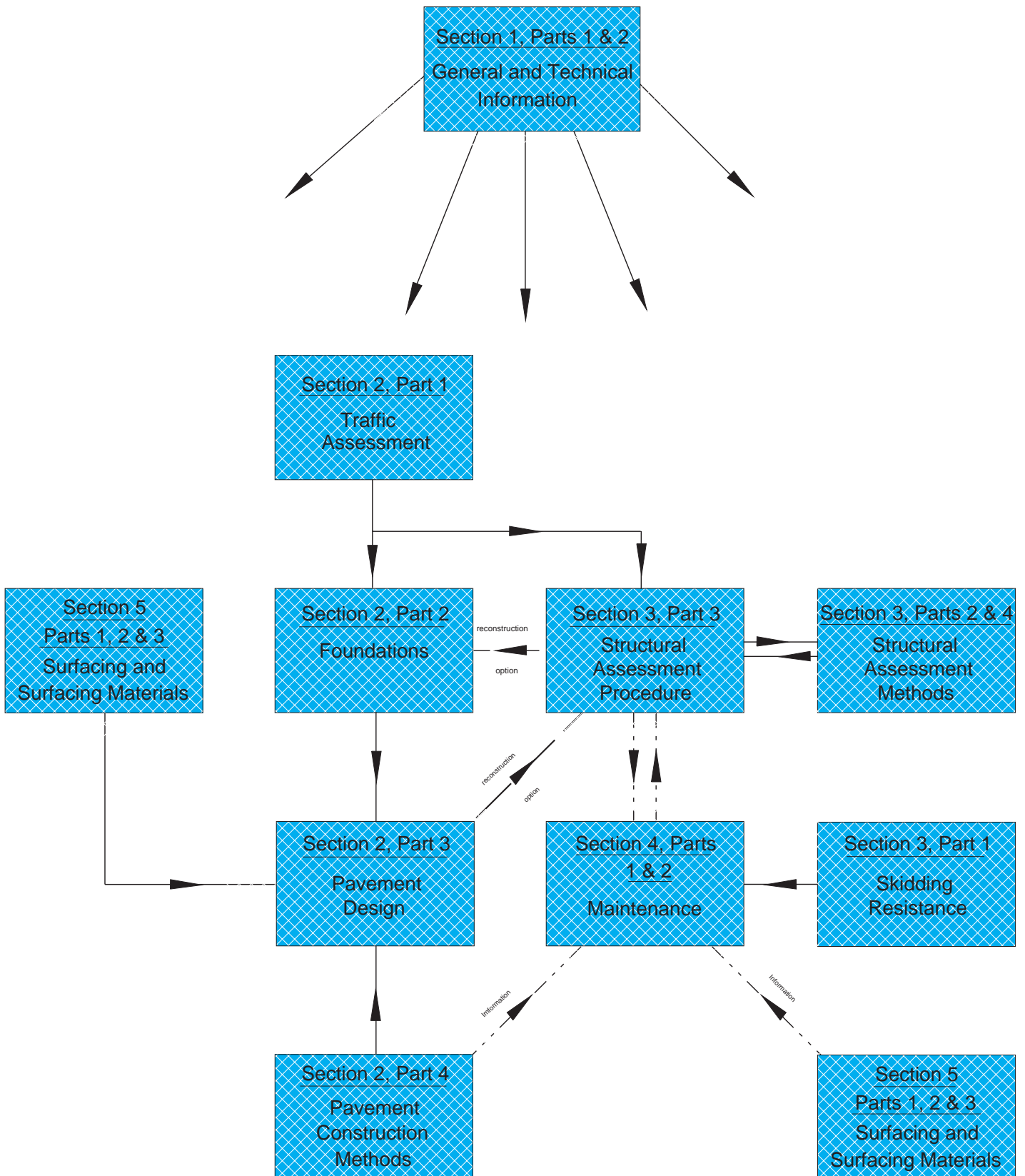


FIGURE 3.1 Use of Volume 7

4. GLOSSARY OF TERMS

Capping :	A subgrade improvement layer, protecting the subgrade from damage.	Foundation :	All materials up to the top of sub-base.
Chainage :	Distance along a carriageway from a reference point.	Growth Factor :	The proportional increase/decrease between the average 'whole life' traffic flow on a road and the flow at opening (or present flow).
Crack and Seat :	Process whereby a failed concrete pavement is broken into relatively small slabs and compacted prior to overlaying.	Growth Rate :	The annual percentage increase in vehicle flow.
Deflection :	The recoverable movement of the surface of a pavement under a transient load.	Inlay :	The replacement of some of the layers of an existing pavement with new materials, ie. a form of partial reconstruction to existing or to different levels.
Deformation :	The irreversible movement/compression of pavement layers, leading to rutting and settlement.	Macro-Texture :	The visible roughness of a surfacing material, enabling drainage of water etc.
Design Period :	The number of years for which a pavement is designed.	Mega-Texture :	The degree of smoothness of the surface with wavelength between 50 and 500mm.
Design Traffic :	The predicted traffic occurring over the design period: usually expressed in terms of millions of standard axles (msa).	Micro-Texture :	The microscopic properties of the surface which enable it to develop friction and thus to provide skidding resistance.
Elastic Modulus :	A measure of the material stiffness properties.	Modulus :	The ratio, stress/strain.
Fatigue :	The formation of cracks in pavement materials under repeated loading.	Overlay :	The placement of new material directly onto the surface of an existing pavement.
Flexible :	Bituminous roadbase and surfacing.	Pavement :	All layers above formation.
Flexible Composite :	Cement bound roadbase, bituminous surfacing.	Profile :	The variation of the longitudinal level along the length of a carriageway.
Formation :	Level upon which sub-base is placed.		

Reconstruction :	The replacement of some or all layers of an existing pavement with new (or recycled) materials.	Vehicle Category :	Description of vehicle by general weight/damaging power, eg, 'Other goods vehicle category 2 (OGV2)'.
Rigid :	Concrete roadbase and surfacing.	Vehicle Class :	Description of vehicle by type and number of axles eg. '3 axle Articulated' or 'Buses and Coaches'.
Rigid Composite :	Concrete roadbase, bituminous surfacing.		
Roadbase :	Main structural layer of pavement; placed above sub-base.		
Standard Axle :	An axle with an 80kN total force.		
Stiffness Modulus :	The equivalent of elastic modulus but for materials whose stiffness varies (eg. with temperature, stress state etc.)		
Sub-base :	A platform layer upon which the main structure of a pavement may be laid.		
Sub-Formation :	Top of subgrade level if a capping is used.		
Subgrade :	Soil underlying a pavement (may be fill material).		
Surface Dressing :	A single/double/triple layer of aggregate combined with one or more layers of binder to form a running surface.		
Surfacing :	Upper layers designed to carry traffic directly.		
Thin Surfacing :	Thin surfacing systems are machine-laid proprietary mixes that have the capability to regulate and smooth surface profile, restoring surface texture and skid resistance.		

5. PRINCIPAL ABBREVIATIONS

AADF	Annual Average Daily Flow	HDM	Heavy Duty Macadam
AAV	Aggregate Abrasion Value	HMB	High Modulus Base
ASTM	American Society for Testing and Materials	HGV	Heavy Goods Vehicle
BS	British Standard	HRA	Hot Rolled Asphalt
BSI	British Standards Institution	HRM	High speed Road Monitor
CBM	Cement Bound Material	HSTM	High Speed Texture Meter
CBR	California Bearing Ratio	ITSM	Indirect Tensile Stiffness Modulus
CHART	Computerised Highway Assessment of Ratings and Treatments	JRC	Jointed Reinforced Concrete Pavement
COBA	Cost Benefit Analysis	LL	Liquid Limit
CRCP	Continuously Reinforced Concrete Pavement	LLAMA	Long Life Approach to Maintenance Assessment
CRCR	Continuously Reinforced Concrete Roadbase	MARCH	Maintenance Assessment Rating and Costing for Highways
C_u	Concrete Cube Strength	MCHW	Manual of Contract documents for Highway Works
cv/d	Commercial Vehicles per Day	MCV	Moisture Condition Value
DBM	Dense Bitumen Macadam	msa	Millions of Standard Axles
DBM50	Dense Bitumen Macadam - 50 Penetration Grade Binder	MSSC	Mean Summer SCRIM Coefficient
DCP	Dynamic Cone Penetrometer	MTM	Mini Texture Meter
DMRB	Design Manual for Roads and Bridges	NAMAS	National Measurement Accreditation Service
DSR	Dynamic Shear Rheometer	NDT	Non Destructive Testing/Nuclear Density Test
EVA	Ethylene Vinyl Acetate	NESA	Network Evaluation from Surveys and Assignments (Scotland)
FWD	Falling Weight Deflectometer	NRTF	National Road Traffic Forecast
GGBS	Ground Granulated Blast Furnace Slag	NSRS	National Skidding Resistance Survey
GPR	Ground Probing Radar	OGV1	Other Goods Vehicle - Category 1
HAPAS	Highway Authorities Products Approval Scheme	OGV2	Other Goods Vehicle - Category 2
HAPMS	Highways Agency Pavement Management System		

OSGR	Ordnance Survey Grid Reference	SMA	Stone Mastic Asphalt / Splitt Mastix Asphalt (Germany) / Stone Matrix Asphalt (USA)
Pa.s	Pascal second (viscosity)		
PA	Porous Asphalt	SMTD	Sensor Measured Texture Depth
PAV	Pressurised Ageing Vessel	SRV	Skidding Resistance Value
PANDEF	Processing and Analysis of Deflections	STEAM	Scottish Traffic and Environmental Appraisal Manual
PCV	Proportional Change in Variance	TAM	Traffic Appraisal Manual
PDPBT	Portable Dynamic Plate Bearing Test	TRL	Transport Research Laboratory
PFA	Pulverised Fuel Ash	TRMM	Trunk Road Maintenance Manual
PI	Plasticity Index	TRRL	Transport and Road Research Laboratory
PQC	Pavement Quality Concrete	TFV	Ten Percent Fines Value
PRD	Percentage Refusal Density	URC	Unreinforced Concrete Pavement
PSV	Public Service Vehicle	UKPMS	United Kingdom Pavement Management System
PSV	Polished Stone Value		
PVA	Poly Vinyl Acetate	VCS	Visual Condition Survey (for concrete surfaced roads)
QUADRO	Queues and Delays at Roadworks	WLC	Whole Life Cost
RTFOT	Rolling Thin Film Oven Test		
SAMI	Stress Absorbing Membrane Interlayer		
SBR	Styrene-Butadiene-Rubber		
SBS	Styrene-Butadiene-Styrene		
SCRIM	Sideway force Coefficient Routine Investigation Machine		
SFC	Sideway Force Coefficient		

6. ENQUIRIES

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