

ASPHALT SURFACINGS



Edited by J.C. Nicholls

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Asphalt Surfacing

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Asphalt Surfacing

A Guide to Asphalt Surfacing and
Treatments Used for the Surface Course of
Road Pavements

Edited by

Cliff Nicholls

Transport Research Laboratory

E & FN SPON

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London and New York

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Preface

This book has been written as a reference book to explain the various asphalt surface course (or wearing course) materials and surfacing treatments that are currently available to engineers. It is not intended to cover the lower, structural layers but reference is made to these layers where appropriate because the properties of all layers interact in producing the required pavement. The book is intended for practising and aspiring maintenance engineers, contracting engineers and consultants who need a clear reference to help them select the materials and/or treatments that are appropriate for use on specific sites. Once it is decided which of them are appropriate, it should then be easier for the engineer to prepare job specifications and/or tender returns for, or to order or apply, a technically correct solution for specific situations.

The contents are intended to explain both the current established position in the United Kingdom, and (to a lesser extent) other parts of Europe, as well the emerging developments that are taking place. Hence, all the main materials and treatments that can be expected to be used for surfacing for the medium term should be covered. The time that this medium term will actually last depends on what new ideas emerge over the next few years, but the industry is relatively conservative and new ideas usually take several years to emerge.

The authors have been selected as acknowledged authorities on their particular topics. They were selected so as to include some from each part of the 'highway engineering industry'—contractors, material suppliers, highway authorities and research establishments. This should achieve a balance between the various approaches required by the different functions they carry out. However, with the moves towards design, build and maintain forms of contract as well as externalization of many local authority functions, the distinctions in those functions are becoming more blurred and all the authors have had to gain an appreciation of the requirements of other professionals in the industry.

The following brief biography of each of the contributors (in alphabetic order) gives an idea of the combined breadth of their experience:

PETER BELLIN, BD, Dipl-Ing, MSc(CE)

Peter is chief engineer for highway pavement engineering, including materials and testing, at the Niedersächsisches Landesamt für Strassenbau (State Highway Agency of Lower Saxony) in Hanover, Germany. In this post, Peter is responsible for many aspects of road pavements, but he has particular interest in specifications, quality assurance, testing asphalt and the construction and maintenance of asphalt pavements.

Peter graduated with a diploma in Civil Engineering, majoring in highway engineering, from the Technical University of Hanover, Germany, in 1961 before working under a

training programme with federal and provincial authorities to gain his civil service licence in 1965, a prerequisite for a career as a chartered engineer in the road administration. He then obtained a Master of Science degree from the University of Wisconsin in the United States of America before starting his professional life in the road authority in 1967 as deputy chief engineer of the district office for the reconstruction of the Autobahn near Hamburg. Between 1988 and 1990, he was attached to the Strategic Highway Research Program (SHRP) in Washington, DC, where he fostered the introduction of the stone mastic asphalt technology into the LTPP-Specific Pavement Studies. From then until 1993 he was a member of the SHRP asphalt advisory committee.

Peter is a member of the German Highway and Traffic Research Association and has been active in several working groups concerned with the specification and quality assurance of asphalt; asphalt pavements; aggregates; and waterproofing systems for bridge decks. He has been a member of the CEN TC 227/WG 1, Bituminous Mixtures, since 1990.

CHARLES CATT, MIHT, FIAT

Charles set up as a private consultant on pavement material since taking early retirement as materials engineer for Warwickshire County Council. He has worked on several research projects, mainly on behalf of the Transport Research Laboratory (including research into an alternative 'quiet' material which is durable, analysis of road survey detail and preparation of footway maintenance and design manuals) and of Acland Investments Ltd as well as advising clients on materials problems.

Charles studied at Birmingham University and then joined Tarmac Civil Engineering in 1961 as a site engineer on major road schemes before transferring into the laboratory. In 1967 he moved to Warwickshire County Council as a laboratory engineer, where he remained until his retirement in 1994, rising to materials engineer. As materials engineer, he was responsible for running the materials testing laboratory (which gained NAMAS accreditation in about 1990), for providing advice on various aspects of materials, and for investigating problems with, and failures of, materials. He also led the Mercia Quality Assurance scheme set up by Warwickshire County Council with Staffordshire, Hereford & Worcester, Shropshire and West Midlands Councils.

While with Warwickshire, Charles represented the County Surveyors' Society on the British Standards Institution committee B/510/2 on surface dressing and the Institute of Petroleum panel ST-E-6 on modified bitumen tests as well as several ad hoc task groups. He was Vice-Chairman of the CSS south-west materials group between 1980 and 1994 and the author of the Highways Authorities Standard Tender Document on surface dressing, HASD 4 for several years.

STEPHEN CHILD, BSc, DIP HC&M, MICE, MIHT, MIAT

Stephen is the Group Engineer responsible for managing the Materials and Construction Management Group within the Engineering Consultancy Division of Surrey County

Council. The work of his group covers a wide range of materials across routine maintenance, design and construction as well as a site supervision service. He is also the Delegated Engineer responsible for the training of graduates and technicians.

Stephen trained as a Chartered Engineer with Surrey County Council, after which he was appointed Geotechnical and Materials Engineer in the Materials Group. He spent a short time in the private sector with Howard Humphreys as a Principal Engineer in Highway Maintenance. In November 1985, he was awarded the IHT Diploma in Highway Maintenance and Construction, winning the Bomag Prize.

Stephen is involved with the County Surveyors' Society as Secretary to the South East Soils and Materials Engineers' Group, Chairman of the Data Collection Working Party, Skidding Resistance Sub-Group and a member of several other working parties. He represents the County Surveyors' Society on several British Standard Committees including B/502, Aggregates; B/502/2, Aggregates for Concrete; B/502/6, Testing of Aggregates; and B/510/5, Surface Characters. In addition, he is vice-chairman of the South East Branch of the Institute of Asphalt Technology.

IAN DUSSEK, FIHT, FIAT

Ian is a director of Wells (Trinidad Lake Asphalt) Ltd and its associated companies, now part of Associated Asphalt Ltd. His principal role is the marketing of Trinidad lake asphalt and providing technical support for its use, both in the United Kingdom and throughout much of the world. As such, he has been involved with many prestigious highway, bridge and airport projects. Other involvements include plant sales and mastic asphalt contracting in the Caribbean.

On leaving school at St Lawrence College, Ian joined the family business at the laboratory of Dussek Bitumen & Taroleum Ltd. In 1960, he was appointed assistant to the technical director of Previté & Company Ltd and was based at the Fulham laboratories of Limmer & Trinidad Lake Asphalt Company Ltd. In 1962, Ian spent six months in Rhodesia in charge of mastic production and technology, as well as assisting in the development of epoxy resin components for building and civil engineering work. At the end of this time, Ian returned to the family business which became part of the IBE group, including Lion Emulsions and Colas Products, although the group was purchased by Shell International Petroleum Company in 1969. Following two years in the contracting industry, specializing in concrete treatment and texturing, he rejoined the Trinidad lake asphalt industry in 1975.

Ian has taken many posts, including President, of both the Institute of Asphalt Technology and the Institution of Highways & Transportation, as well as of the Worshipful Company of Paviers. He is a member of several British Standards Institution and allied committees, including the Structures Maintenance Committee of the US Transportation Research Board.

TERRY FABB, BSc, FIAT

Terry is the Technical Director of the Refined Bitumen Association (RBA) in which role he chairs the RBA's Technical Committee, acts as technical spokesman for the UK bitumen industry and represents the RBA in the European Bitumen Association (Eurobitume).

Terry had a long career at the BP Group Research Centre at Sunbury-on-Thames. His work there covered the product development of petrochemicals, lubricants and fuels and, for the last twenty years of that career, bitumen. During the last eight years of his work for BP, he was the Project Leader responsible for the BP Group's research, development and technical service on bitumen and asphalt. His own R&D efforts included work on low-temperature cracking (for which he received the annual 'Emmons' award of the Association of Asphalt Paving Technologists) and high-temperature rutting (for which he received the annual Argent award of the Institute of Asphalt Technology jointly with Vince Hayes). He also received the Argent award in 1993 for a paper on the case for using porous asphalt in the United Kingdom.

Terry has been secretary of the CEN Working Group responsible for the preparation of harmonized European specifications and test methods for paving grade bitumens since its formation in 1990, and is a member of the corresponding CEN Working Group for asphalts. He is also a member of several British Standards Institution and Institute of Petroleum committees.

PETER GREEN, BSc

Peter is Manager of the Bitumen Technical Unit at the BP Research and Engineering Centre at Sunbury, Middlesex. He has been involved in, and is now responsible for, many projects in support of BP's bituminous activities worldwide. These projects include the development of processing routes for bitumen; bitumen quality; measurement and interpretation of bitumen rheology and its relation to performance; and the development, testing and production of speciality products including modified binders and emulsions.

Peter graduated in 1976 from Kingston University with a chemistry degree and joined BP's Group Research Centre to work on the development of a range of oil products for various applications. In 1984, he transferred to the Bitumen Technical Unit to work on the development of bituminous products. Peter has written and contributed to several papers on bitumen rheology and asphalt properties and sits on the Institute of Petroleum Panels ST-E, Bitumen Tests; ST-E-1/2, Bitumen Rheology; and ST-E-6, Modified Bitumen.

BILL HEATHER, BA, FIHT, MIAT

Bill is the Technical Director for Associated Asphalt Ltd. His responsibilities include the

introduction of new special products and processes, which have included Safepave thin surfacing and Glasgrid reinforcement mesh.

Bill started his career as a research assistant for British Drug Houses before moving to the research laboratory of the British Transport Commission. He joined Constable Hart & Company Ltd, where he worked in black-top contracting for eight years before moving to ARC as an area manager. In 1975, he joined Associated Asphalt as an area manager and then regional manager before taking on increasing responsibility for technical matters. He joined the Board of CAMAS Associated Asphalt in the beginning of 1994, which became Associated Asphalt Ltd in 1997.

Bill is a long-standing member of the ACMA Technical Panel; BSI Committee B 510/1, Bituminous Mixtures; CEN TC 227/WG5, Surface Characteristics; and a number of other British Standards and specialist committees concerning the roads industry. Recently, he has joined the British Board of Agrément Highway Authorities Products Approval Scheme (HAPAS) Specialist Group SG3, Thin Surfacing.

JUKKA LAITINEN, MIAT

Jukka is Technical Manager of Associated Asphalt Ltd, where he is responsible for the day-to-day management of Associated Asphalt Pavement Technology. AA Pavement Technology provides comprehensive technical support to the company, including the latest technical facilities for research and development and a fully independent NAMAS laboratory providing extensive services to in-house and external clients, which include consultants, contractors and highway authorities in the United Kingdom and overseas on both highway and airfield projects.

Jukka joined the Central Laboratory of Limmer and Trinidad in 1968, gaining a very broad based knowledge of pavement materials and their testing, including bridge and airfield surfacings. In 1972, he joined Associated Asphalt (subsequently CAMAS Associated Asphalt, now Associated Asphalt Ltd), where he has primarily worked on technical aspects with extensive experience of production management of both static and mobile units. He was closely involved with the development of various products and processes during this period, including the day-to-day production and application of all types of materials. He has a wide range of experience of both highways and airfield contracts in the United Kingdom, Caribbean, Middle and Far East due to his company's involvement in these areas.

Jukka is currently Chairman of the Institute of Asphalt Technology South Eastern Branch and is a member of the IAT Education Committee, which he represents on the Laboratory and Associated Technical Standards Initiative. He is part of a BACMI/LTA working group on the specification for asphalt sports surfaces. Additionally, he has recently joined the British Board of Agrément Highway Authorities Products Approval Scheme (HAPAS) Specialist Group SG2, Overbanding.

DAVID LAWS, CEng, MICE, MIHT, MIAT

David is the Head of Materials Division at Stanton House in Huntingdon, which is part of the East Anglia regional operation of W S Atkins Consultants Plc. The Laboratory undertakes a wide range of testing and supervisory services with full materials consultancy back-up.

David trained as an Engineering Learner with Hertfordshire County Council and completed his training with Ross and Cromarty County Council in their west coast out-office in Dornie. He then worked for Huntingdon and Peterborough County Council, becoming Design Team Leader before being appointed Chief Resident Engineer in Peterborough with Cambridgeshire County Council with the 1974 Local Government reorganization. In 1978 he was appointed Soils and Materials Engineer, became Departmental Quality Control Manager in 1991 and Divisional Manager, Laboratory, in 1992 as part of the Cambridgeshire County Council Engineering Consultancy which, in April 1995, transferred to W S Atkins under a hosting agreement.

David is a member of BSI Committees B/507, B/509/2 and B/510/1, has been an original member of the CSS/TRL Haunching Working Group and is now on the steering group of the Linear Quarry Project. He has also been a member of the HAUC Specifications Working Party since its inception and is one of the Authority nominees as a Certification Panel member for PCSMs. He has been involved with the new developments in thin surfacings since some of the first trials in the United Kingdom during 1991 were on the A1 and A47 in Cambridgeshire; he is currently involved with the monitoring and reporting on the trials covering Safepave, UL-M and stone mastic asphalt on the A1 and A10 together with contractual operation of the performance-based specification of rolled asphalt which involves wheel-track testing of rolled asphalt cores at 60 °C.

COLIN LOVEDAY, FIHT

Colin is Director of Tarmac Heavy Building Materials Ltd, where he has recently completed 25 years working mainly in the fields of asphalt, aggregates and road construction and maintenance.

Colin is Chairman of the Asphalt Technical Committee of the British Aggregates & Construction Materials Industries and a member of the Technical Committee of the European Asphalt Pavement Association, chairing their Task Group on Quality and Certification. He is the chairman or a member of several CEN sub-committees and task groups within TC 154, aggregates, and TC 227, road materials, and of the BSI shadow committees.

CLIFF NICHOLLS, MPhil, BSc(Eng), ACGI, DIC, CEng, MICE, MIStructE, MIAT, MIHT

Cliff is a Project Manager in the Civil Engineering Resource Centre at the Transport Research Laboratory. He is mainly involved in asphalt surface course materials, from rolled asphalt to surface dressing and including porous asphalt, high-friction surfacings

and thin surface course materials, but has also carried out research on associated materials such as road markings and trench re-instatement to the HAUC criteria.

Cliff graduated in Civil Engineering from Imperial College, University of London, in 1972 to join Rendel Palmer & Tritton, where he worked on steel bridge design and on site at the Thames Barrier. He moved to the Property Services Agency in 1976 where, after a short period in the design office, he was sent back to IC to get his second degree for research into reliability analysis. In 1980, he moved to the Department of the Environment to act as technical secretary to the various UK Eurocode Technical Panels before returning to research in 1983 at the Civil Engineering Laboratory and then the Concrete Laboratory of the Building Research Establishment. He moved to the Transport and Road Research Laboratory (now the Transport Research Laboratory) in 1986 and took up his present position, and with it an interest in asphalt materials, in 1988.

Cliff represents TRL on several British Standards Institution Committees (B 510/1, Bituminous mixture; B 510/1 WG2, Sampling and Testing of Bituminous Mixtures; B 510/2, Surface Dressing and Slurry Surfacing; and B 510/19, Bitumen), Institute of Petroleum Committees and Panels (ST-E, Bitumen Tests; ST-E-1/2, Bitumen Rheology; and ST-E-6, Modified Bitumen) and British Board of Agrément Highway Authorities Products Approval Scheme Specialist Group (SG1, High-Friction Systems; and SG3, Thin Surfacing) as well as being a BSI delegate on CEN TC227/WG1/TG2 on Test Methods for Bituminous Mixtures. Cliff is also a committee member of the Construction Materials Group of the Society of Chemical Industry.

STEVEN St JOHN, FIHT, MiMgt, MIAT

Steven is Quality Manager for Colas Ltd, in which post he is responsible for ensuring the maintenance and enhancement of Colas' registered quality assurance systems. In addition, he is responsible for supporting business improvement activity within the organization, as well as with its suppliers and customers, and he is also closely involved in international business development.

Steven's background is in specialist contracting, most of it related to highways. His main work experience has been in highway surface treatments, including surface dressing, slurry surfacing and retreat. He has been closely involved in surface dressing development with several different companies, working in France, Austria and Scandinavia as well as the United Kingdom. After three years with South Western Tar Distilleries, he joined Colas Roads in 1986. Since then, he has led the team which was responsible for surface dressing the M25 in Kent in 1990, the first motorway surface dressing carried out at night. In 1991, he gained the Professional Diploma in Management from the Open University, which included a dissertation on quality assurance and total quality. He became Quality Manager for Colas Ltd in 1994 and International Business Manager in 1996.

Steven has been a member of the Technical Committee of the Road Surface Dressing Association since 1981. As well as writing some of the RSDA publications, he is a frequent lecturer on their training courses and has been a member of joint RSDA/County Surveyors' Society working parties on traffic signing and on quality assurance. He is a

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Dr TONY STOCK

Tony is currently working as a consultant with Stock Tynan Associates, specializing in Pavement Engineering with a global practice, which supports both industry and clients. Dr Stock is also a Visiting Professor at the University of Westminster.

Tony's career in Pavement Engineering started at Surrey University with work on concrete and cement-bound materials. This interest was developed at Nottingham University, developing the first computer program for the design of flexible pavements; the project was sponsored by the Asphalt and Coated Macadam Association and led to the award of a doctorate. Tony then joined the Civil Engineering Department at Dundee University, where he continued with research on Pavement Engineering and on recycling. As a lecturer, he was responsible for research into recycling bituminous materials with support from the Research Council and from the Scottish Division of Tarmac; this work laid some of the technical foundations for the implementation of recycling in the British Isles.

Tony has also been a Visiting Professor at Texas A&M University and has spent a significant period of time working with the Corps of Engineers in their Waterways Experiment Station in Vicksburg, Mississippi. In 1988, Tony joined British Petroleum Research at their research centre in Sunbury-on-Thames as a research associate and leader of the Bitumen R&D team. At this time, he was also a member of the Industrial Advisory Group to the Strategic Highways Research Program. Since leaving BP, Tony was Professor and Head of Civil Engineering at Sheffield Hallam University before setting up his consultancy practice, to which he gives his full attention.

Prof. ALAN WOODSIDE, MPhil, CEng, FICE, FIE Ireland, FIAT, FIQ, FIHT,
MCIWEM

Alan is the Director of the Highway Engineering Research Centre in the School of the Built Environment at the University of Ulster as well as holding a personal chair in Highway Engineering since 1994. He leads a staff of researchers and technicians providing a research and consultancy service to the profession as well as providing numerous short courses, both in Northern Ireland and abroad. Alan supervises 15 major research projects which are being sponsored by government and industry from the United Kingdom and abroad.

Alan commenced his training as an Engineering Assistant in 1965 with Larne Borough Council, progressing to Assistant Engineer in 1970. In 1972 he moved to the Joint Engineering Department for Ballymena Borough and Rural District Councils before moving to academia in 1973 when he became a Lecturer in Civil Engineering at the Northern Ireland Polytechnic. Teaching at sub-degree, degree and postgraduate level on many courses, he was promoted through Senior Lecturer to Principal Lecturer by 1982.

He was then appointed Senior Lecturer at the University of Ulster and progressed to Reader in Highway Engineering in 1990.

Alan is the Chairman of the CITB (NI) Black Top Committee and the British Standards Committee TG9 on the Durability of Aggregates as well as being a representative on the Comité Européen de Normalisation committee for aggregates. He has also been a Board Member of the Association of Municipal Engineers, a member of the Association of Municipal Engineers Northern Ireland Committee, a member of the Institution of Civil Engineers (Northern Ireland Committee) and a member of the Institution of Highway Engineers (Northern Ireland Committee).

J.C.Nicholls
Editor
3 March 1997

CHAPTER 1

Introduction

J.C.Nicholls, Transport Research Laboratory

1.1 HISTORICAL DEVELOPMENTS

Before discussing the material types currently available and used for surfacing asphalt, or 'blacktop', roads, it is as well to have an appreciation of the historical development of road construction. This is the development of the pavement structure and not the road network.

The first roads were probably developed from animal tracks, where the only construction was route markers to avoid marshes and other inhospitable features (Hindley, 1971). These tended to hold to high ground, such as on the Downs in the United Kingdom, to allow the traveller clear vision and, hence, safety. As human beings became more settled, genuine construction began to be incorporated by clearing the route. Removed stones were often used to build lines of cairns, or even low walls, which served to mark the road. In some parts of the world, the construction even went as far as to include artificially levelling the road, the building of embankments and the digging of ditches.

The earliest paved roads tended to have been block paving in urban areas (which were very limited at that time) and 'corduroy', or log, roads in soft ground conditions. Block paving appears to have started in the Middle East, with bitumen being used for brick and stone bonding as early as 2000 BC, including for the processional roads in Babylon. A typical construction of a corduroy road had a bed of loose branches above which was laid timbers about 100 mm to 150 mm thick parallel to the direction of traffic and finally cross-pieces or sleepers about 75 mm thick. The earliest known examples of corduroy roads in Britain were in Somerset and date back to 4000 BC, in which the surface was obtained by splitting the length of the logs. However, constructed roads are only really necessary when society is based on cities, so fully constructed roads did not really emerge until the ancient empires arose, in particular the Roman Empire.

Roman roads were not all constructed in precisely the same way, the method employed depending on both the local conditions and importance of the route. For the major routes, the ground was usually levelled and aggers, or drainage ditches, dug along both sides of where the road was to be built. Pavement constructions used included:

- placing a foundation of heavy stones over which was laid broken bricks or pottery; and
- excavating the road to a depth of a metre before being filled with loose aggregate and then finished with close-fitting block paving.

When crossing marshy ground, they first laid logs which they covered with rushes to

separate the oak from the damaging effect of the lime used as a cement mortar in the road construction. A typical construction is illustrated in Figure 1.1, a cross-section of the Appian Way.

Following the fall of the Roman Empire, the importance of cities diminished and, hence, the need for roads reduced, as well as the loss of an organization capable of constructing and maintaining them. Therefore, there was little true road building during the Middle Ages until the Industrial Revolution and the general movement away from an agrarian economy. In the United Kingdom, the revival of road construction occurred with the advent of toll roads; the leading figures in this era were Thomas Telford (1757–1834) and John Loudon Macadam (1756–1836).

The construction method developed by Telford had a layer of uniformly large stones as the foundation, overlaid by smaller graded aggregate; all the aggregate was carefully washed and sieved prior to use. Macadam also used carefully graded aggregate, but omitted the base layer of large stones. The pavement surface of roads by both were moderately cambered with the gradings being selected so that the surfacings would be sealed with the dust produced by heavy, slow-moving horsedrawn wagons filling any exposed gaps.

The overall structure of Telford's pavements was relatively thick and hence very strong, while that of Macadam's pavements was cheaper, but less robust. The need for the additional strength was widely argued at the time, but both types were better engineered, and hence significantly stronger and more robust, than the typical road pavements previously. The spread of such all-weather roads from being restricted to major conurbations extended the potential for mobility of both people and goods.

While the principal unit of power for vehicles was the horse, the main interest in surface characteristics was in the smoothness of the surface on which the wheels rolled and, to a lesser extent, the grip that the horse could obtain. However, while horse-drawn traffic caused any detritus to help seal the road, the higher speeds that arrived with the

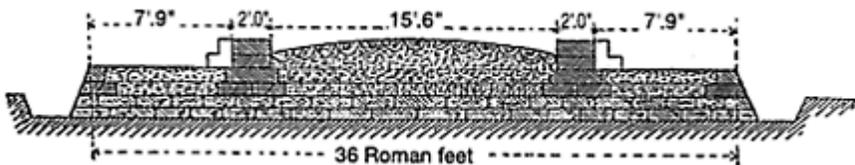


Fig. 1.1 Cross-section of a Roman road (the Appian Way)

automobile meant that these finer particles tended to rise, resulting in great clouds of dust. Initially, measures to reduce the dust included the use of water-bound 'macadams', but the most successful measure was to bind it with tar.

The idea of pre-mixing the aggregate skeleton, or 'macadam', with tar binder before it was laid, so producing a tar-bound macadam, or 'tarmacadam' (section 6.2.1) was first tried in the 1830s before the era of cars. Initially, there was great rivalry between woodblocks, which were quiet, and tarmacadam or asphalt, which were durable and sanitary. However, tarmacadam developed the predominate place in the early twentieth century such that all asphalt is 'tarmac' to the general public. This term has become

increasingly inappropriate because bitumen has replaced tar as the most common binder for asphalt paving materials. This change occurred in the United Kingdom because:

- town gas, the main source of coal-tar being a by-product in its manufacture, was replaced by North Sea gas in the 1970s;
- there was increasing concern about the carcinogenic effects of the polycyclic aromatic compounds found in tars; and
- the viscosity of bitumen is less susceptible to changes in temperature than that of tar, resulting in less seasonal variation in performance.

Other asphalt materials were developed which gave impermeable surfacings that would not produce dust as well as resist permanent deformation. The availability of Trinidad lake asphalt (section 3.3) resulted in its being used to produce an asphalt, or mastic, mortar (Chapter 8), generally for use on city streets. The addition of a proportion of larger sized aggregate to bulk up the mortar resulted in the concept of rolled asphalt (Chapter 5), with the predominant binder changing through pitch bitumen to petroleum bitumen. Another method of binding the aggregate that was developed was to spray coaltar onto the surface, together with an application of some relatively fine aggregate to soak up excessive binder and give grip. This developed into surface dressing (otherwise known as chip seal in the United States of America and some other countries), which is currently used as a maintenance technique for bound, as well as unbound, pavements (section 11.1).

In recent years, communications have fostered a greater interchange of ideas between countries, as well as the increase in the traffic levels imposing greater stresses on pavements, so that there is perceived benefit in developing further material types, and then ‘exporting’ them. These include stone mastic asphalt (Chapter 9) and the thin surface course systems (Chapter 10). Further developments have occurred with pressures to reduce the environmental impact of roads in terms of less traffic noise and/or spray, which can be achieved using materials such as porous asphalt (Chapter 7).

Some ‘imports’ to the United Kingdom have had to be modified slightly because of the emphasis placed on the safety of roads by the UK Department of Transport (now the Department of the Environment, Traffic and the Regions). The UK skidding policy has helped to make the United Kingdom among the safest countries in the world in terms of the number of accidents and fatalities per kilometre driven. Despite only the main roads ‘belonging’ to the Department (or Scottish Office, Welsh Office or Department of the Environment for Northern Ireland in those countries), the other highway authorities in the United Kingdom have tended to follow the lead of these Departments. The main roads belonging to the Department and operated by the Highway Agency, or to the other Government Departments, are the trunk roads; 2537 km of motorways and 8088 km of all-purpose roads which form the strategic network. The remaining roads ‘belong’ to the relevant local authority, with local authority roads representing 96% of the length of roads in the United Kingdom, but carrying only 69% of the total, and 46% of the commercial, road traffic.

There are, therefore, many different bodies responsible for the public roads in the United Kingdom. Similarly, there are different methods of managing the road network in Europe and elsewhere. Different bodies have different ideas as to what characteristics are