Highway maintenance handbook

Highway maintenance handbook

Second edition

Edited by
Ken Atkinson, CEng, MICE, MIHT

Thomas Telford

Published by Thomas Telford Publications, Thomas Telford Services Ltd, 1 Heron Quay, London E14 4JD

First published 1990
Second edition 1997

Distributors for Thomas Telford books are
USA: American Society of Civil Engineers, Publications Sales Department, 345 East 47th Street, New York, NY 10017-2398
Japan: Mauruzen Co. Ltd, Book Department, 3–10 Nihonbashi 2-chome, Chuo-ku, Tokyo 103
Australia: DA Books and Journals, 648 Whitehorse Road, Mitcham 3132, Victoria

Front cover picture credit to SIAC Construction, photograph taken by Studio 18.

A catalogue record for this book is available from the British Library

ISBN-13: 978-07277-2531-8

ISBN: 0 7277 2531 9

Printed by Lightning Source

Preface

In preparing the second edition of the *Highway maintenance handbook,* the authors have endeavoured to update references where appropriate and address some of the significant technical and operational changes that have affected highway maintenance since the book was first published.

The evolutionary nature of maintenance and the necessary caution exercised by its practitioners tends to restrict the rate of change, but there is no doubt that this once low-key activity has become and will remain an important function in the management of the nation's infrastructure.

The authors hope that the revised edition will assist those engaged in this field of engineering.

The editor wishes to thank Parkman Limited for assistance in the preparation of this second edition, and in particular the help given by Kevin Bishop and Stuart Hodgson.

The contribution from George Lecky on claims in Chapter 2 and the updating of Chapter 5 by Atkins Odlin Limited and Chapter 9 by Dr A. E. Young are appreciated.

Thanks for the efforts made by all authors in preparing revisions, and to those who kindly loaned photographs or supplied information.

Ken Atkinson

Contents

Ken Atkinson

1. Introduction

In recent years, highway maintenance has become a relatively high profile topic, due perhaps to the greater travel potential of the general public, and also to the impact of roadworks on commerce since the swing away from rail transport. From being a specialized but none the less 'Cinderella' occupation, maintenance is now being treated as a deservedly important consideration in the overall cost of providing highways. For most construction, the maintenance requirement can be predicted in terms of a series of actions required to keep the initial components in a state of acceptable serviceability. This usually entails the establishment of appropriate intervention levels in the lifespan of each material or member, allowing recovery of its performance before such time as full replacement is needed. Unfortunately, the dual pressures of workload and resource limitation frequently prevent this idealized procedure from taking place, and economies are lost. Such loss of performance and potential savings are not surprising given the long-term nature of maintenance and the difficulties of persuading the controllers of finance that attention is needed, which may not be apparent to the layman.

The purpose of this book is to give an insight into some of the facets of highway maintenance, which are practised or under development, to aid both the engineer engaged in the discipline, and those needing to know more about this field of activity. With such a diverse and often complex subject, the full range of topics cannot be covered, but a selection has been made to show the areas of 'general maintenance' in which most money is commonly spent. Reference is also made to techniques used to establish the basic needs and programmes. The authors have drawn from experience gained in local government, contracting, academic research, and consultancy fields, and most chapters also offer sources of further information.

1.1. The highway scene

Failure to provide and maintain vital communication links affects every household, either directly in terms of travelling time, or indirectly in the mounting costs of supplying goods, vehicle damage, accident costs, and

the loss of competitive edge against vying commercial interests elsewhere. Roads have assumed an increasingly important role in this process, particularly during the past 30 years, and as a result of the motorway building programme. In total some 365 000 km of public road serve the nation, and these are divided into various categories as shown in Table 1.1.[1.1] Improvement in major road links has encouraged the transfer of bulk haulage from traditional rail transport to such an extent that predictions of road life expectancy, using estimates of the cumulative totals of standard axles, have been far exceeded. Figure 1.1 illustrates this growth in terms of road category. In addition the character of vehicles in use has altered towards the larger and heavier end of the spectrum. Inevitably, this large increase has shortened the life of roads and has increased the cost and frequency of maintenance needed to keep them serviceable. The overall condition of roads has however stabilised in many categories during the past 5 years except for Urban Classified and Urban Unclassified. This is due to the considerable efforts of government and highway authorities and their agents.

Forward planning and the estimation of traffic needs is difficult, and subject to many indeterminate changes — Table 1.2 shows changes that occurred in London in the period 1984 –1994.

This switch of some 20% away from private transport, is indicative of the difficulty in travelling by road, and the increasing attraction of commuting by public transport. A further change in attitudes has been the willingness of commuters to travel extended distances, balancing the extra cost against perceived improvement in environment, and lower prices in the more remote positions. Many factors will influence future trends in road usage, including

Table 1.1 Public road length by class of road and country 1994: km

	England	Wales	Scotland	Great Britain
Motorways:				
Trunk	2696	123	274	3092
Principal	44	0	31	76
Dual Carriageway:				
Trunk	3013	—	476	3489
Principal	2190	—	283	2474
Single Carriageway:				
Trunk	4661	1577*	2384	8622
Principal	23 383*	2662*	7272*	33 318
B roads	20 120	2916	7311	30 347
C roads	62 128	9674	10 303	82 105
Unclassified roads	160 796	16 757	23 892	201 445
Total	279 031	33 709	52 226	364 966

*The single carriageway figures include dual carriageway lengths where these are not separately available.

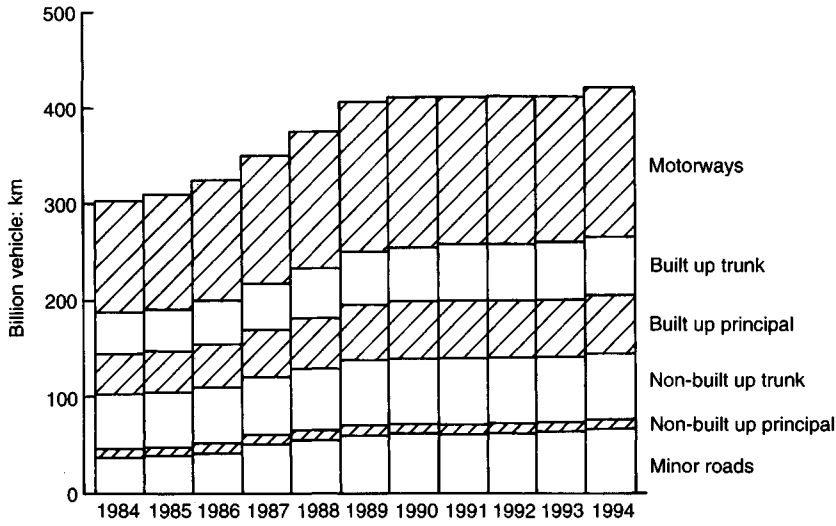

Fig. 1.1. Traffic increase for the period 1984–94 on each class of road. (Source: Transport Statistics Great Britain 1996)[1.1]

(*a*) the success of policies to divert development to less crowded areas
(*b*) the impact of physical and political changes in Europe, such as the Channel Tunnel, and trade barrier legislation
(*c*) the redevelopment of existing urban areas.

Against this background of variables and uncertainties, politicians and their advisers face the task of determining levels of finance and activity, which will maximize the benefits, and minimize the disadvantages of the road network. Not least among these factors are the emphasis and resources to be allocated to the important category of highway maintenance. There are clear signs that the time for giving priority to this work is now, before the escalation in road damage reaches uncontrollable proportions. Dependence on a natural process of deterring travel by the sheer difficulty involved, may well work for non-essential journeys, but in the process has disastrous effects on necessary commerce.

Current thinking suggests that transport efficiency will once again come to rely on the railway system, but this will require a considerable change in the outlook of road users, who have become accustomed to the flexibility and convenience of door-to-door transport. Such a reversal of attitude will not take place quickly enough to stem the increasingly costly effects of road congestion.

The environmental impact of major new building has prompted ideas such as the use of rail routes for elevated roads, and restricted finance has led to consideration of sources other than the public sector for road

and bridge building. Schemes involving ways in which prime locations can be priced and/or restricted, greater flexibility in working hours, and reduction in the benefit of company car use have all been included in appraisals of the traffic problem. Highway maintenance is undoubtedly a key factor in all such deliberations, including all works within the highway which have an effect on either traffic or the integrity of the highway structure. Among the more recent strategies, are the Private Finance Initiatives such as Design Build Finance and Operate (DBFO), and alternatives for maintenance only. Whatever the evolutionary changes in transportation practices and methods, common sense dictates that the under-cared for and over-used elements of the existing system need to be nursed in a structured programme of repair for the foreseeable future.

1.2. Relevant facts

During the past two decades, spending on local roads has fallen, whereas traffic has shown a marked increase. The number of licensed vehicles in 1994 was approximately 25·2 million, and this total is expected to rise. The trend towards the use of heavier vehicles is expected to continue, and it remains to be seen whether this will lead to a decrease in the total numbers of goods vehicles. At present, 85% of all goods are carried by road, and this practice is likely to continue.

Spending on highway maintenance in 1994–95 in England was at an

*Table 1.2 People entering central London during the morning peak 7–10 a.m.: thousands**

	British Rail		LUL and DLR only	LT bus	Coach/ mini-bus†	Private car	Motor-cycle	Pedal cycle	All modes
	Total	Transfers to LU/ DLR							
1984	386	134	350	94	25	180	16	10	1061
1985	401	152	364	94	26	171	15	11	1082
1986	421	166	381	91	25	166	13	8	1105
1987	449	186	401	79	21	161	11	8	1131
1988	468	188	411	80	21	160	10	7	1157
1989	473	179	390	73	23	161	13	10	1142
1990	458	188	368	70	20	158	11	9	1094
1991	426	169	347	74	20	155	12	9	1042
1992	401	156	337	61	24	150	11	9	992
1993	382	168	340	64	20	150	11	9	977
1994	392	171	346	63	23	145	11	9	989
Percentage change over:									
1 year	3	2	2	−2	−15	−3	—	—	1
10 years	2	28	−1	−33	−8	−19	−31	−10	−7

*In addition to journeys terminating in central London, all journeys passing through central London are included, except those entirely on London Underground
†Includes commuter and tourist coaches
Source: British Rail/London Transport

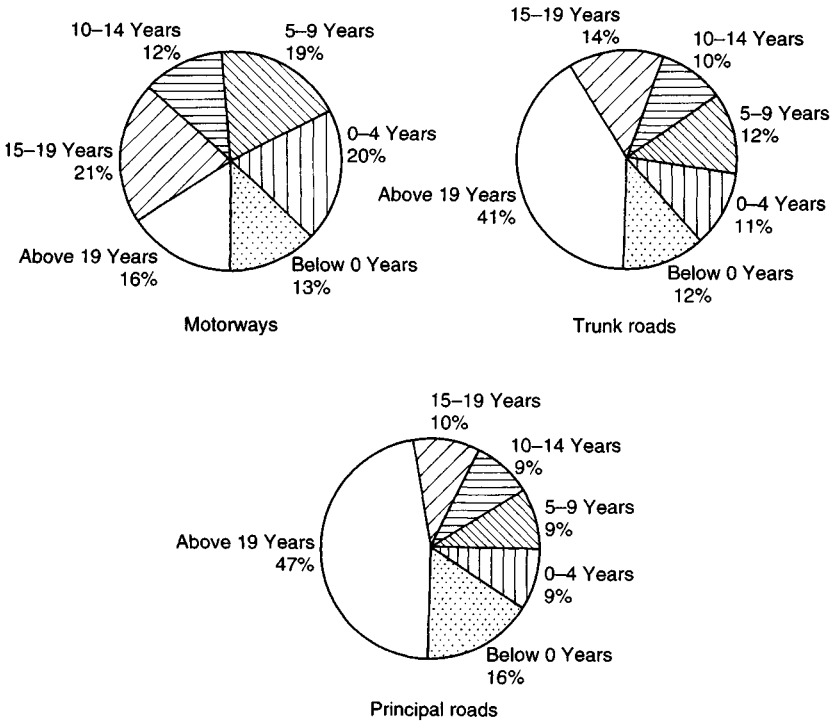

Fig. 1.2. Distribution of residual life: England and Wales 1994

annual level of £811·6 million for trunk roads and motorways and £1461·2 million for local roads. The results of the National Road Maintenance Condition Survey (NRMCS) indicate that some 25% of urban principal roads and 23% of trunk roads have a residual life of less than five years (see Fig. 1.2).

1.3. Definition of highway maintenance

In engineering, the term 'maintenance' is used to describe the processes of sustaining construction elements in a safe and usable condition. There are also benefits in appearance and cleanliness to be gained from regular attention. From the time of production, construction components begin to decline as a result of weathering, use, and changes occurring in physical and chemical conditions. The aim of maintenance is to carry out protective and repair measures designed to limit the detrimental effects of these natural or imposed processes, thereby prolonging the useful life of the construction. The effectiveness of maintenance is improved if action is taken before major deterioration takes place, and is likely to be most efficient if done in a preplanned manner.

For most major components, a relatively long life is expected in the highway context, ranging from say five years for surface dressing of carriageways to perhaps some hundreds of years for major structures, such as bridges and tunnels. Each aspect and item forming the highway therefore needs consideration in developing a programme involving inspection, design of remedial treatments, contract preparation, implementation and

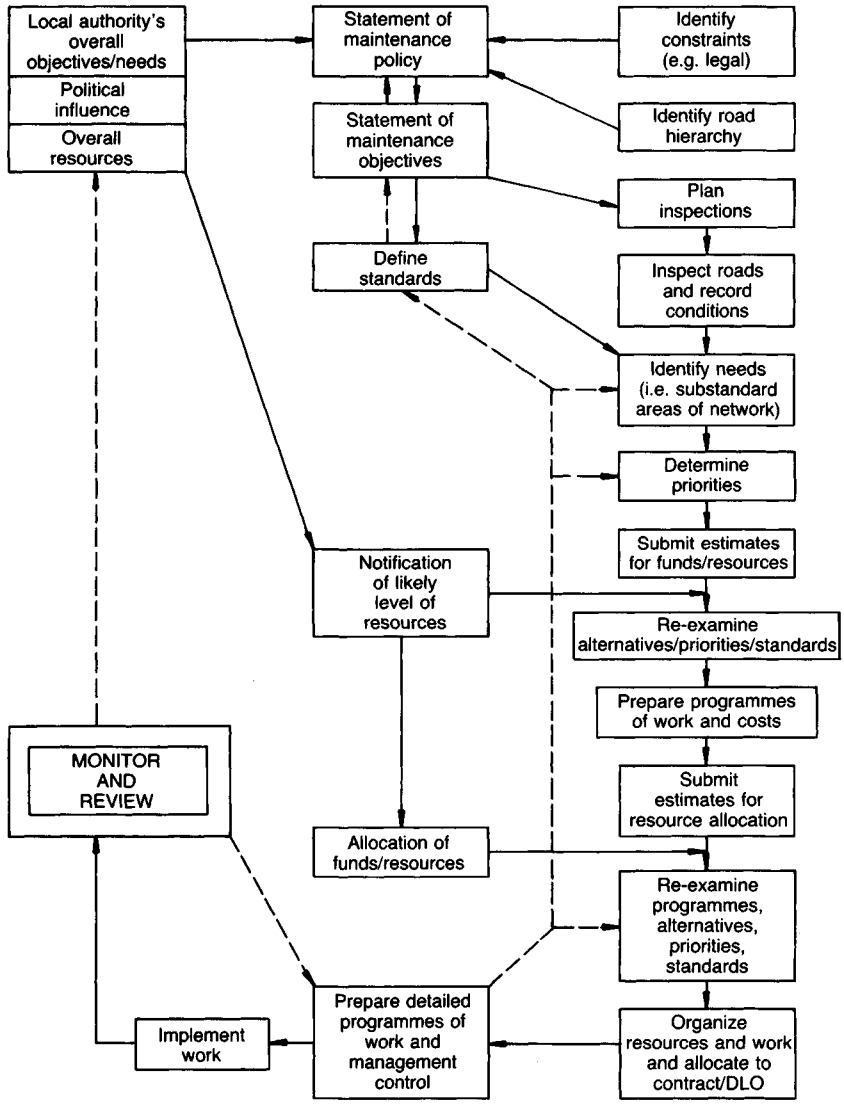

Fig. 1.3. Maintenance management flow diagram

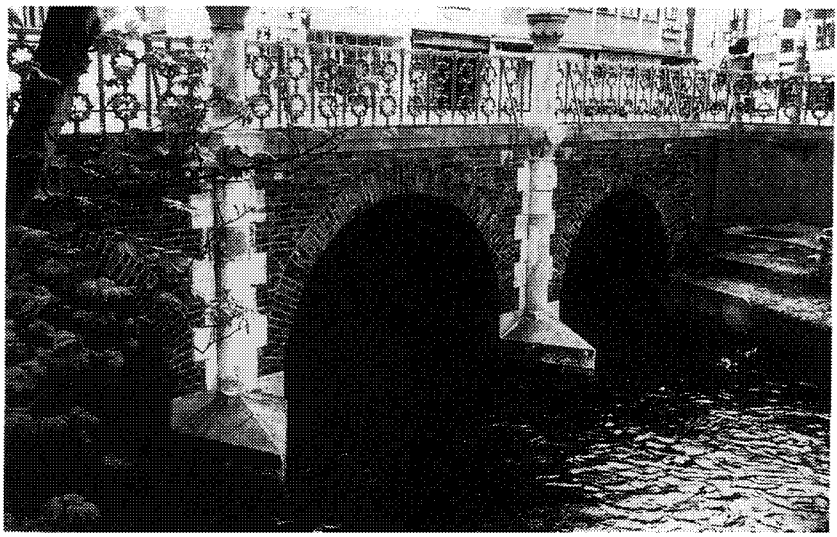

Fig. 1.4. Clattern Bridge, Kingston-upon-Thames

monitoring of results. Also, with the exception of accident damage, the process of decline permits a variable response timescale and introduces the need to choose between frequent minor attention and less frequent but more costly major work. Such decisions, made jointly between the maintenance engineer and the owner, form the crux of the art of maintenance, and may be summarized as follows.

(*a*) Identify and assess conditions.
(*b*) Define and cost alternative actions and respective consequences.
(*c*) Obtain necessary approvals and finance.
(*d*) Institute a programme of work including the frequency of intervention and the scale of regular work required.
(*e*) Carry out periodic monitoring of the results achieved. Figure 1.3 shows a typical management flow chart.

1.4. Importance of records and monitoring

Adequate records of item (*e*) form the basis of experience on which reliable future judgements can be made, and without which sensible comparisons between methods, materials used and costs become difficult. Care is needed to avoid false economies, which in the short term offer savings, but result in a shortened lifespan or inferior service. While structures often demonstrate a surprising capacity to withstand the ravages of time and abuse, it is unwise to depend on such characteristics without carrying out systematic inspections and assessments.

Figure 1.4 shows a small arch bridge in London, built in the 12th century, and today carrying full highway loading without apparent distress.

Figure 1.5 shows a Victorian bridge of more elaborate form, which, due to material and structural changes, is now limited to a maximum loading of 2 tonnes and requires constant surveillance. Such examples illustrate the difficulty in predicting future conditions at the design stage. A further well known case is the early motorways, where design assumptions were exceeded within one-third of the anticipated lifespan in some cases. Present generations owe a debt to predecessors, whose wisdom, and investment, provided a generous capacity in design, and high quality in construction. This is not to say that design should automatically be over-conservative, but that the sensitivity of costings to increase in design capacity should be related to a timescale.

1.5. New techniques and materials

The development of new techniques and materials is an important feature of maintenance work, and requires cooperation between producer and user. In highway maintenance this means mutual assistance between client, specifier, research organizations such as the Transport Research Laboratory (TRL) at Crowthorne, consultants in the field of materials testing, specialist contractors, many of whom conduct programmes of research and development, and manufacturers, who again give support and advice in the choice and use of available and developing products. A typical sequence of events is

(a) the identification and production of a new commodity or technique
(*b*) laboratory and initial field trials, perhaps extending over months or even years
(*c*) engaging the help of a highway authority or owner to carry out limited scale trials in a working location, and under full exposure

Fig. 1.5. Albert Bridge, London

to traffic, using normal operatives and plant, and carefully monitoring the results

(*d*) full-scale use of the product under working conditions, again with a recording of method and performance.

Such trials may be at the expense of the supplier, or in the later stages can involve the client in a reasonable part of the costs, preferably with the protection of a guarantee clause in the arrangements.

1.6. Usage of the highway

With the exception of motorways and certain designated special roads, highways are available for use by all classes of traffic, including cyclists, pedestrians and horses. Legislation covers the manufacture and use of vehicles and all aspects of street furniture, signing and the behaviour of road users. Practitioners of highway maintenance need to be familiar, for instance, with the requirements of Chapter 8 of the Traffic Signs Manual[1.2] covering temporary road works signing. Overall, highway authorities have a duty, under section 41 of the Highways Act 1980,[1.3] to ensure that roads are in a safe condition for traffic likely to use them. In recent years a pronounced change has occurred in the methods of distributing goods, resulting in a major increase in the number and gross weight of traffic using the highway. The maximum vehicle weight permitted without special consent varies, depending on axle and wheel configuration, as detailed in the Construction and Use Regulations,[1.4] but a further upward increase will take place in accordance with Article 3 of the Council of the European Communities Directive 85/3 to unify the regulations with the types of vehicle used in Europe. From 31 December 1998, the maximum weight for 'combined vehicles' within the United Kingdom will generally be increased to 40 tonnes. The majority of roads are all purpose facilities, serving both local and through traffic. The carriageways and footways are also available to statutory authorities for the laying and maintenance of necessary pipes and mains, under powers conferred by the New Roads and Street Works Act 1991.[1.5] More recently, the safety aspects of all construction works, including the design, have become the subject of further legislation, the Construction (Design and Management) Regulations 1994.[1.6] Although all these aspects are subject to controlling powers by Highway Authorities and their agents, the overall effect presents the maintenance engineer with a considerable challenge. A summary of legislation commonly encountered is shown in Appendix A.

1.7. Funding of highway maintenance

Government expenditure on roads is derived from a three-year plan of public expenditure, which is reviewed annually. The Minister for Transport, responsible for roads, will compete for funds against other demands made on the available money, and arrive at a listing of approved schemes or cash

levels for allocation. Unsuccessful items are deferred for later consideration the following year, or reintroduced if further money becomes available. Strict control is exercised over the total amount of public spending. Councils receive funds from rates generated finance, Rate Support Grant (RSG) and Transport Supplementary Grant (TSG), other Agents receive annual allocations for the various categories of maintenance.

RSG is supplied by Government and is calculated using a formula according to such factors as population, road mileage and numbers of children of school age. While this item is intended to cover local road maintenance the councils are not obliged to allocate in the same ratio as the formula, and frequently set priorities with a different emphasis. Experience has been that some of this grant is diverted.

TSG relates to expenditure on capital works, i.e. for projects of more than local importance. Such schemes are identified in prepared lists of Transport Policies and Programmes (TPPs) submitted to the Department of Transport, giving details of schemes for the next financial year and outlining plans for a further four years. Trunk road maintenance, carried out by highway authorities (and appointed consultants) acting as agents for the Department of Transport, is funded separately according to a programme of capital renewal and current maintenance estimates. All other road maintenance is funded from RSG and local rates income. There are also isolated instances of income from toll charges and bridge funds. Arguments are sometimes presented for the acceptance of certain maintenance schemes as qualifying for capital expenditure. A process of direct bidding and funding occurs where private consultancies undertake management of highway maintenance, a trend which is increasing.

These procedures changed as a consequence of the Local Government

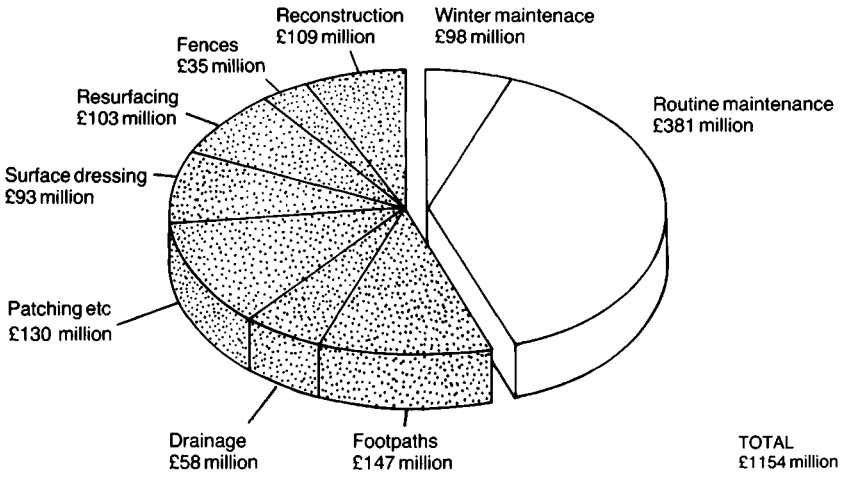

Fig. 1.6. Expenditure on highway activities