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A STUDY OF FOOTWAY MAINTENANCE

FOOTWAY MAINTENANCE WORKING GROUP

Edited by Marilyn H Burtwell

Prepared for: The Working Party on Highway Research

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Transport Research Laboratory
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CONTENTS

A STUDY OF FOOTWAY MAINTENANCE

This report has been prepared by the Transport Research Laboratory at the request of the Footway Maintenance Working Group, set up by the Working Party on Highway Research chaired by Mr T W Thompson, Director of Planning and Transportation, Leicestershire County Council, to report on the range of present UK footway maintenance practice, to highlight good practice and identify areas where research may be needed.

The full membership of the Working Group is as follows:

G K WOOD	(Chairman) Assistant County Surveyor, Shropshire County Council
M H BURTWELL	(Secretary) Principal Scientific Officer, TRL Civil Engineering Resource Centre
L HAWKER	Principal Engineer, Highways Agency, Department of Transport
D HARRISON	Materials Engineer, Humberside County Council
L B KADERBHAI	Principal Engineer, Mid-Glamorgan County Council
P STAPLES	Divisional Surveyor, Leicestershire County Council
J J PRICE	Principal Engineer, Roads Service, Maintenance Works, Belfast Division, Department of the Environment
D I PEARSON	Consultant Civil Engineer (formerly Sheffield City Council)
M S SNAITH	Professor of Highway Engineering, University of Birmingham
P E DICKINSON	Assistant Director Highway Maintenance, Leeds City Council

A STUDY OF FOOTWAY MAINTENANCE

PREFACE

In recent years footways have been the subject of little research despite being a major part of urban highways and residential areas. The increase in litigation following pedestrian injury accidents has highlighted the need to invest in the design, construction and maintenance requirements of footways including assessment of the cost benefits of surface treatment against reconstruction. The introduction of the New Roads and Street Works Act 1991 and the code of practice issued under the Act entitled Specification for the Reinstatement of Openings in Highways (DOT et al 1992) is also likely to have a significant effect on the condition of the footway.

It is estimated that Local Authorities each spend between £3m and £4m annually on footway maintenance. The average County spends about 25 per cent of its structural maintenance budget on footway repairs, whereas in District and Metropolitan areas the figure is nearer to 50 per cent.

In October 1991, the Working Party on Highway Research set up a Footway Maintenance Working Group to address all aspects of footway maintenance and to report firstly, on the present range of UK footway maintenance practice and, within that range, to highlight good practice and secondly, to identify areas where research may be needed.

The Report compiled by the Working Group is based on information obtained from a questionnaire survey of the Department of Transport (DOT), Department of the Environment (DOE) Northern Ireland, Scottish Office (SO) and thirty highway authorities and may, therefore, reasonably be considered to reflect the situation throughout the UK.

The group's initial aims were to consider and report upon:

- causes of footway problems
- development of improved materials and repair techniques
- development of equipment and techniques to economically monitor footway condition
- definition of warning levels and intervention criteria
- application of whole life cost concepts
- methods of management
- design and construction
- needs of the mobility handicapped
- current footway research

Thirty main highway authorities or agent authorities responded to the questionnaire (as shown in Table 1).

TABLE 1

List of Authorities Contacted by the Footway Maintenance Working Group

County Councils	Metropolitan and District Councils	Government Department
Bedfordshire	Barnsley	DOE (Northern Ireland)
Clwyd	Birmingham	
Gwent	Calderdale	
Hertfordshire	Cleethorpes	
Humberside	Coventry	
Leicestershire	Doncaster	
Lincolnshire	Harrogate	
Mid Glamorgan	Hull	
North Yorkshire	Kirklees	
Northamptonshire	Leeds	
Shropshire	Rochdale	
South Glamorgan	Rotherham	
	St Helens	
	Salford	
	Sheffield	
	Trafford	
	Wigan	

EXECUTIVE SUMMARY

The full Report consists of nine chapters, each with its own summary. The Annexe provides a summary of the main findings from the questionnaire survey. Brief details of the contents of each chapter are given below. Current maintenance practice is described, and where appropriate, good practice and research needs are highlighted.

CHAPTER 1. Methods of Management describes the various techniques which provide the benefits of reduced costs, increased productivity, uniform levels of service and improved quality of maintenance. It presents information on the Codes of Practice in current use and comments on the various systems available to assess and prioritise highway and specifically footway maintenance. It was found that 70 per cent of the 30 authorities who responded to the questionnaire had defined maintenance standards and 60 per cent had a formally defined maintenance policy. Fifty per cent replied that allocation of funds were needs led. Benefits arising from improved methods of management include allocation of maintenance funds on the basis of need and a reduction in the number of complaints and claims made by the public.

CHAPTER 2. Design and Construction considers the broad areas of geometric, structural and other factors which can be applied to the provision of new footways and the rehabilitation of existing footways. Present available guidance on structural design essentially deals with modular footways. Bituminous footway construction thickness although widely specified uses the parameters of custom, practice and experience. Specifiers are starting to consider aesthetic factors as well as structural design, to minimise damage, reduce whole life costs and reduce the numbers of liability claims. Existing practical knowledge and experience, published research and empirical test results need to be related to formulate a rationalised design and construction guide for footways. The effectiveness of performance models needs to be compared to determine those most appropriate for use in footway design. Models need to be tested for sensitivity to traffic loading, foundation strengths and construction type. Further research to provide a formal design guide for all types of construction is recommended.

CHAPTER 3. Causes of Footway Problems identifies four main factors, namely poor design and specification; faulty construction; abuse and; fair wear and tear, and suggests ways of overcoming them. Control and supervision of the utilities was considered to be a significant problem. In addition, 75 per cent of the Authorities targeted in the survey indicated that there was a need to reduce vehicle overrun and agreed that design standards and construction methods needed improvement. About 30 per cent of the estimated £300 million spend on footway repairs is on non-programmed work; only ten per cent of the budget was used for preventative maintenance.

CHAPTER 4. Materials and Repair Techniques discusses the range of both British Standard and proprietary materials which are available, highlights the need for the greater use of recycling, the need to collect performance data and the identification of specific areas of research. The selection and development of materials with adequate storage life and appropriate surface and performance characteristics are predominant issues. The considerable opportunity afforded to highway authorities by the co-ordination of field trials, new developments into the performance assessment of footway surfacings is stressed. The RAPID database is eminently suitable for this purpose. The potential use and effectiveness of recycling techniques is also stressed.

CHAPTER 5. Monitoring Equipment and Techniques deals with the various types of visual and machine-based processes in present use. The need to develop additional machine-based quantitative condition assessment techniques is discussed. Many authorities are aware that the controlled use of footway profilometer, capable of accurately measuring and recording surface defects, could reduce the incidence and costs of litigation. Research to assess the performance of two footway profile measuring devices, leading to an end product/performance specification is described. It should be cost effective and portable and be suitable for a range of footway surfaces.

CHAPTER 6. Warning and Intervention Levels comments on the definition of standards of service against which a rational funding argument can be developed and hence an effective system of maintenance management. Of the authorities surveyed, 70 per cent indicated that they had set standards for maintenance. Budget restraints were noted as a factor inhibiting the definition of maintenance standards for footways. Development of deterioration curves are discussed with a view to providing realistic warning and intervention levels based on consumer survey and economic evaluation. There is a need for research to establish realistic warning and intervention levels which can be interfaced with Whole Life Cost maintenance procedures and user requirements.

CHAPTER 7. Whole Life Costing sets out the methodology within which this technique can be applied. The trade off between construction and maintenance costs is discussed, and practical pointers are given for the implementation of a whole life costing approach. Three fundamental steps in securing funds for the management of the infrastructure are considered, viz; justifying what funds are needed on a rational basis, prioritising how the funds are spent and evaluating the effectiveness with which the funds are spent.

CHAPTER 8. Needs of the mobility handicapped sets out the special requirements and considerations that are necessary to cater for the vulnerable members of society. Recommendations are given on the use of a variety of tactile surfaces to aid the visually handicapped. These recommendations have been adopted by many authorities and the use of tactile surfaces at the approaches to pedestrian crossings is now widespread.

Research indicates that higher standards of maintenance and design are required by the physically handicapped. However, a balance in the allocation of funding is needed because if funds are diverted from normal maintenance to meet disabled needs, then personal injury claims from the able bodied may increase introducing an unacceptable level of added expenditure to the settlement of litigation claims. More research is needed to identify areas most used by the handicapped where higher standards can be economically applied.

CHAPTER 9. Current Footway Research in the UK is set out in this chapter and it is clear that limited research is being undertaken to improve footway condition, overall performance and investment in the improved infrastructure. An earlier report by the Standing Committee on Highway Maintenance (SCHM) in 1979-80 identified the need to provide better information about the scope of improved management in terms of the techniques used and policy, including improved cost effectiveness. Two research projects - provision of a design guide for footway construction is currently being undertaken and development of an end product/performance specification for a footway profilometer has been completed. Other areas of future research under review include, warning and intervention levels, whole life costing, performance of cold-laid materials, hot and cold recycled materials, problems associated with overrun, tactile markings and surfaces for the blind and compaction equipment for use on footways with restricted manoeuvrability.

ANNEXE TO THE MAIN REPORT summarises the main findings obtained from 30 County, Metropolitan and District Councils. Full details are available from the Transport Research Laboratory (TRL).

CHAPTER 1. METHODS OF MANAGEMENT

CONTENTS

CHAPTER 1. METHODS OF MANAGEMENT

SUMMARY

The primary objective of footway maintenance is to keep footways safe and comfortable for pedestrians, with some regard for the appearance, ensuring that overall expenditure is both cost-effective and justified in terms of the present and future use of the footway. A higher standard of maintenance is required today, emphasised by the increasing litigation following pedestrian injury accidents. Improved methods of management need to provide benefits of reduced costs, increased productivity, uniform levels of service and improved quality of maintenance work. Information should also be provided for public and legislative enquiries and support for budgetary requests of the organisation.

Although maintenance systems exist, the survey of highway authorities showed that 30 per cent of the authorities questioned had no defined maintenance standards.

Maintenance needs can arise due to general deterioration, localised damage or specific deterioration. Methods of condition assessment are defined and standards and warning levels are incorporated into a maintenance management system. Maintenance funds can be allocated on the basis of need. Details on treatment options, the cost-effectiveness of maintenance options, trends and budget can also be provided. Fifty per cent of the authorities surveyed replied that their maintenance funds were needs led; ten per cent stated that allocation of funds was historically led.

Information is presented in this Chapter on the Codes of Practice in current use and the various systems available to assess highway and footway condition such as Routine Management Maintenance System (RMMS), Computerised Highway Assessment of Ratings and Treatments (CHART), Maintenance Assessment, Rating and Costing for Highways (MARCH) and UK Pavement Management System (UKPMS).

1. INTRODUCTION

Footways have long been a neglected part of the highway infrastructure. Today, a higher standard of maintenance is expected and this is emphasised by the increasing litigation following pedestrian injury accidents. Costs associated with maintenance of footways have increased significantly in the last decade. Improved methods of management need to provide benefits of reduced costs, increased productivity, uniform levels of service and improved quality of maintenance work. They should also provide information to answer public and legislative enquiries and to support their organisation's budget requests.

The primary objective of footway maintenance is to keep footways safe and comfortable for pedestrians, with some regard for the appearance. Maintenance needs can arise due to general deterioration, localised damage or specific deterioration. As a main objective, a method of condition assessment should be defined and standards and warning levels set. These should then be integrated into a maintenance management system. The allocation of funds can then be provided on the basis of need. Information about other factors such as treatment options, cost effectiveness of maintenance options, trends and budgetary considerations are also required.

Any maintenance system can be defined as controlling resources to accomplish a predetermined level of service by means of:

a) Planning and prioritising work requirements

b) Budgeting to meet work requirements

c) Scheduling to achieve budget objectives

d) A reporting system

e) Performance assessment

Basic components include:

a) Inventory and locational referencing system

b) Collection of condition data

c) Policies on maintenance standards

d) Planning, budgeting and work implementation procedures

e) Performance monitoring and evaluation

2. NATIONAL ROAD MAINTENANCE CONDITION SURVEY - NRMCS

The NRMCS survey is sponsored jointly by the Local Authorities Associations, the Department of Transport and the Welsh Office. The survey is designed to provide statistically significant information about trends in carriageway and footway condition. It provides information on a defects list for seven classes of carriageway and footway. From this defects list, a further list is built up by weighting together the results for individual defects according to their relative cost of repair.

The length of footways in England and Wales according to the NRMCS Report on the 1993 survey (1994) is estimated to be 239 000 kilometres, distributed as shown in Table 1 below:

TABLE 1

Distribution of Footways in England and Wales

Road type	Length (thousands km)	Per cent of total network %
Trunk	4	1.7
Urban	219	91.6
Rural	16	6.7

Overall footway condition in 1993 was similar to that in 1992. Following the deterioration in 1986, it is now steady at the pre-1986 level. The 1993 survey gives another measure of footway condition, namely the average number of 'trips' i.e. hazardous spot defects. In 1986 these were on average around one in every 40 metres of footway, but have now improved to one in every 60 metres. The proportion of footway deterioration was stable at about 20 per cent from the start of the NRMCS surveys until 1985 when it increased to 25 per cent in 1986 falling to the previous level again by 1990. Levels of deteriorations have fallen since, those in 1993 being the lowest since surveys began. Footway deterioration and the incidence of 'trips' is now highest on rural principal and rural classified roads.

3. CODES OF GOOD PRACTICE

3.1 LOCAL AUTHORITY ASSOCIATION (LAA) CODE OF GOOD PRACTICE

During the pre-1983 period, it was generally accepted that the various highway maintaining authorities nationally were approaching the question of highway maintenance with no apparent consistency even though all expenditure was the subject of careful scrutiny. The Local Authorities' Association, therefore, set up a joint study team to prepare a comprehensive Code of Good Practice (1st edition, 1983) using the Report of the Committee on Highway Maintenance (Marshall Report) published in 1970 as its starting point.

The objectives of the study team were:

(a) To encourage Highway Authorities to use a systematic approach to decision making within a consistent framework.

(b) To provide a common basis for assessing the overall maintenance need, resource requirement and implications.

(c) To reduce the then inconsistencies in highway maintenance standards.

(d) To assist in the more effective allocation of national and local resources.

(e) To encourage the regular review of policies, standards and the effectiveness of maintenance programmes.

While many authorities welcomed the first edition of the Code of Good Practice published in 1983, the practical application of the recommendations contained therein was patchy for various reasons. The LAA in collaboration with the Convention of Scottish Local Authorities (COSLA) promoted a second edition (1989) which built on the strengths of the original edition and includes substantial additional information on Highway Management Information Systems (HMIS).

Amongst the several recommendations made in the second edition, the Code stipulates that:

(1) "Highway Authorities should categorise their highway networks on the basis of an urban/rural split taking into account the volume and composition of traffic to a minimum of the levels set out in the Appendices."

Towards this end footways hierarchy has been categorised by the Code in terms of the level of pedestrian usage and therefore does not necessarily coincide with the categorisation of the road classifications. This is detailed in Appendix 3.3 of the Code, which has been reproduced in Appendix 1.A for reference,

(2) "Highway Authorities should institute a visual assessment system with sufficient coverage to enable the changing condition of all categories of highway to be monitored over time so that financial needs can be estimated, funds allocated more effectively and priorities set for the authority including its agents."

For footways, the Code recommends detailed and safety inspection intervals for all defined categories in Section 4(b) which is reproduced in Appendix 1.B for reference.

In an attempt to produce a consistent approach, the Code has defined standards and warning levels which give intervention criteria and type of treatment for the listed modes of deterioration for each category of footway and cycleways within the defined hierarchy. Relevant pages from the Code have been reproduced in Appendix 1.C for reference.

3.2 DEPARTMENT OF TRANSPORT (DOT) TRUNK ROAD MAINTENANCE MANUAL VOLUME 2: ROUTINE AND WINTER CODE

The DOT Trunk Road Maintenance Manual Volume 2: Routine and Winter Code (1992) was produced following concern expressed by the Department about the wide disparity of routine maintenance practice over the motorway and all-purpose trunk roads network.

The Code makes a requirement for safety and detailed inspections to be undertaken at stated intervals in a number of areas of maintenance including that of footways and cycle tracks. The safety inspection frequencies for footways and cycle tracks range from an interval of seven days to one month depending on the category of the road defined in Table 1.2.1 in the Code. For detailed inspections, stipulations of 12 months and three yearly intervals are made for footways and cycle tracks in urban and rural all-purpose trunk roads respectively.

Whilst the defined defects in the Code are in the main similar to the modes of deterioration given in the LAA Code of Good Practice, the response times have been more accurately stated in the former. Defects which represent an imminent hazard require an immediate response, while the others have to be rectified within six months.

4. ROUTINE AND CONDITION ASSESSMENT SYSTEMS

4.1 ROUTINE MAINTENANCE MANAGEMENT SYSTEM (RMMS)

The computerised routine maintenance management system (1986) is designed to store, process and retrieve inventory and inspections data. It incorporates three types of surveys:

(a) Inventory;

(b) Condition; and

(c) Safety.

Nodes, sections and links are used for locational referencing. Information is collected and loaded onto the system for monitoring, analysis and display. Some indication is given of how the data held may be used to obtain better maintenance management and thereby better value for money by producing the following:

(a) Listings of inventory items as checklists for inspectors.

(b) Schedules of inspections to be carried out at a particular time.

(c) Schedules of cyclic maintenance tasks to be carried out at a particular time.

(d) Programmes of work.

(e) Generation of works orders based on inspection records.

(f) Checks on performance of treatments.

(g) Checks on resource requirements.

(h) Time series data on the results of adopting particular maintenance strategies.

4.2 COMPUTERISED HIGHWAY ASSESSMENT OF RATINGS AND TREATMENTS (CHART)

CHART (1975) is a structural maintenance management system which assists in formulating programmes for the structural maintenance of carriageways, footways and kerbs. At present all DOT agents use this system.

The objectives of the system are:

(a) To identify maintenance needs and give an indication of degree of need for treatment which takes into account all defects present, whether critical or not, and which also ensures that no severe individual defect is suppressed merely because it is isolated.

(b) To indicate/suggest treatments to correct the defects identified and measured.

(c) To provide a visual presentation of the structural condition of the road together with some inventory information.

Inspections are commonly carried out on a one to three year cycle. The programme allows lengths of footway that are not within defined standards to be identified and located, and then recommends the types of remedial treatment required to restore the condition to be within the standards. The various treatments are listed in order of priority. The engineer can then decide on implementation based on the available funds.

4.3 MAINTENANCE ASSESSMENT, RATING AND COSTINGS FOR HIGHWAYS (MARCH)

At present MARCH (1975) is used by 48 Highway Authorities, 30 of which are Metropolitan District Councils. Inspections are commonly carried out on a one to three year cycle. The system uses intervention levels related to the quantity of the defect. The defects are aggregated for each section length on the footway and when the deterioration levels exceed user defined intervention levels a treatment is triggered. The treatments are costed and each length is assigned a priority. The system also has network routing capabilities.

4.4 UK PAVEMENT MANAGEMENT SYSTEM (UKPMS)

Item inventory, including footways, will also comprise part of the UK Pavement Management System (UKPMS) currently being developed by the Department of Transport in partnership with Highway Authorities. There will be a minimum of 15 inventory items provided and the system allows for the recording of the details of these items. Collection of inventory items using existing systems will still be possible within the framework of UKPMS.

At present UKPMS has completed its development and trialing. The Logical Design has also been completed and will be followed by the implementation phase and details of the timescale required for the release of the final system. It is expected that other systems will be modified to become compliant with UKPMS. The Logical Design of the system has been released.

The development of UKPMS will facilitate the management of treatment histories for all roads and the application of whole life costing.

The noteworthy features which will make UKPMS different from existing systems are outlined below:

(a) It will cover flexible and rigid pavements, footways and cycle tracks.

(b) A coarse assessment and a detailed assessment with different standards and techniques are proposed for DOT roads and local roads.

(c) A flexible locational referencing approach is proposed which will accommodate existing systems.

(d) Provision for priority ranking on the basis of short term projections of pavement performance instead of current condition.

(e) An economic testing facility to allow the most cost effective treatment for a defective length of pavement to be identified, thus facilitating priority ranking of treatment schemes on the return from investment over a short period.

(f) A PMS data interchange format as a standard means of inputting data from survey machines.

4.5 DEPARTMENT OF THE ENVIRONMENT (DOE) NORTHERN IRELAND-WORK PLANNING SYSTEM

The annual public liability expenditure for Northern Ireland is high. An analysis of the reasons behind this large expenditure indicated that Divisions had different inspection periods, inconsistent definition of defects and different repair periods. The legal profession was limited in the service it could provide, defence of claims was difficult and the overall situation was not helped by the large settlements awarded by jury systems in the courts.

Against this background, the Northern Ireland Roads Service developed a policy of inspection and repair they believed the courts would consider reasonable. Towards this end the following courses of action were taken:

(a) Section Offices were split into Client and Works functions.

(b) Inspection periods for the different categories of roads were agreed between all Divisions.

(c) Defects were categorised and response periods allocated for each category.

(d) A Central Claims Unit was initiated for coordinating the public liability claims work for all Divisions.

In order to comply with all the variables involved, the road authority developed a based computer system with Inspectors using Psion data capture devices to collect the information.

Details of the system together with information on inspection frequencies, typical faults etc. have been given in the paper presented by Mr J Magowan at the Footway Maintenance Seminar held at the University of Birmingham on 9 July 1992.

The total project has been fully implemented since 1989 and Public Liability Claims expenditure is now falling, leaving more time and money to be spent on more cost effective, larger scale reconstruction type work.

An auditable, standardised claims recording system that can be input to a highways claims monitoring system is recommended.

5. THE USE OF MANAGEMENT SYSTEMS

The survey showed that of the 30 respondent authorities, 70 per cent set standards and the remaining 30 per cent had no defined maintenance standards. No formal inspection process was used by 13 per cent of those questioned. It was found that MARCH was the most popular management system, being used by around half of those authorities who had adopted a formal inspection system. CHART was favoured by 15 per cent and the LAA Code of Good Practice was used by a further nine per cent of those authorities who had formalised their inspection process.

Of the 60 per cent of authorities who had a formally defined maintenance policy, 27 per cent stated that the main aim was to provide the public with safe walking surfaces at a minimum cost. The LAA Code of Good Practice was adopted by 13 per cent and a further ten per cent aimed to maintain the structure at a minimum cost.

Fifty per cent of the authorities surveyed replied that allocation of their maintenance funds were needs led; ten per cent stated that allocation of funds was historically based.

The recommendations of the LAA Code of Good Practice were used to decide the frequency of inspection by 38 per cent of those surveyed. An annual inspection was employed by 20 per cent of the authorities, whilst three per cent inspected on a three yearly basis, and a further three per cent had no formally defined frequency of inspection.

6. CONCLUSIONS

Although maintenance assessment systems exist, the survey showed that 30 per cent of the authorities questioned had no defined maintenance standards. The majority of those authorities who did use a method of assessment used MARCH to cost treatments and assign each length a priority rating.

Improved methods of management are needed to provide the benefits of reduced costs, increased productivity, uniform levels of service and improved quality of maintenance work.

Inspection based management systems require realistic, clearly defined, easily understood standards. More work is needed in this area to obtain warning and intervention standards closely related to pedestrian response and expectations.

APPENDIX 1.A: LAA CODE OF GOOD PRACTICE (1989) - APPENDIX 3.3 - FOOTWAYS HIERARCHY

Footway maintenance standards as with carriageway maintenance standards will not necessarily be reflected by the road classification, this being determined by pedestrian usage and not the importance of the road in the network. Local factors such as the age, distribution of the population, the proximity of schools or other establishments attracting higher than normal numbers of pedestrians to the area should also be taken into account. As a general guide four broad maintenance categories are recommended for footways as follows:

Footway Maintenance Category

I Main shopping areas

II Busy urban areas

III Less used urban and busy rural

IV Little used rural

APPENDIX 1.B: LAA CODE OF GOOD PRACTICE (1989) - APPENDIX 3.3.1 - CYCLEWAY HIERARCHY

The 1970s and 1980s have seen an upsurge of interest in cycling which is now seen by many to be a convenient, cheap and healthy mode of transport and exercise.

This has resulted in the increase in the provision of facilities for cyclists, which may be broadly categorised as shown below. In considering maintenance close attention must be given to the surface texture which will have a direct effect on the riding quality and safety of the facility.

Cycle Maintenance

Category	Cycleway classification	Typical construction
A	Cycle lane - forming part of the carriageway commonly 1.5 metre strip adjacent to nearside kerb. Cycle gaps - at road closure point (no entries allowing cycle access).	Carriageway surface may be colour identified - generally red - using paint or by surface dressing.
B	Cycle track - a highway route for cyclists not contiguous with the public footway or carriageway. Shared cycle/pedestrian paths - either segregated by a white line or other physical definition, or unsegregated.	Flexible footway construction usually colour identified by paint, surface dressing, or red wearing course, crossfall preferred to camber.
C	Cycle trails - leisure routes through open spaces. These are not necessarily the responsibility of the highway authority.	Minimal construction often utilising locally available materials.

1(a)(vi) **Adverse Camber**

Range of severity of adverse camber is defined as follows:

Satisfactory	A safe camber, not amounting to a hazard
Bad, where	i. Camber or adverse camber on bends is so excessive that it is potentially dangerous ii. Crossfall insufficient to provide run-off for surface water, causing water to remain on the carriageway, to a potentially dangerous extent.
Very Bad	Extreme cases of i and ii above

Where road safety is prejudiced it may be necessary to shape and resurface offending areas.

1(a)(vii) **Surface Irregularity**

Category to which applicable	Limitation or severity	Percentage of length or area	Treatment
2	220 ins* per mile 3.53 m* per km	100	Resurface
3 & 4	240 ins* per mile 3.85 m* per km	100	Resurface

* as measured by the Bump Integrator

1(b) Footways and Cycleways

Modes of Deterioration

a. Projections (including manhole frames, boxes, etc.)
b. Dangerously rocking flags
c. Cracks or gaps between flags
d. Isolated potholes
e. Depressions and bumps
f. Slippery surfaces

The speed of response will be related to the intensity of use and the degree of danger.

Group to which applicable	Limitation or Severity	Percentage of area	Treatment
I Main Shopping areas		20	Restore surface
IIa Busy urban/shopping (flexible)	Coarse cracking of the surface. Coarse crazing. Depressions more than 25mm deep. Trips greater than 13mm but less than 20mm.	30	Restore surface
IIb Busy urban/shopping (rigid)	Trips more than 13mm but less than 20mm. Cracks or gaps more than 20mm wide and more than 6mm deep. Rocking flags which are not dangerous. Depressions more than 25mm deep.	30	Restore surface
III Less used urban and busy rural (flexible)	As for busy urban (flexible)	40	Restore surface
III Less used urban and busy rural (rigid)	As for busy urban (rigid)	40	Restore surface
IV Little used rural	When potentially dangerous		Patch or restore surface

Note: Choice of surface treatment will depend on the failure mode of construction and importance of the footway or cycleway. Generally less used footways would only require surface treatment and heavily used ones reconstruction of the surface. Although not specified separately, cycleways should be treated to urban standards in normal circumstances.

APPENDIX 1.C

LAA CODE OF GOOD PRACTICE (1989) - 4(b) Surveys and Inspections - Suggested Intervals

	Category	Inspection/Survey Interval Condition	Detailed	Safety
Roads				
2	Strategic Routes	1 year	6 months	1 month
3(a)	Main Distributor	1 year	6 months	1 month
3(b)	Secondary Distributor	1 year	1 year	1 month
4(a)	Local Interconnecting roads	depends on findings	1 year	3 months
4(b)	Local Access Roads	of detailed and safety inspections	5 years	1 year
Footways				
I	Main Shopping Areas	N/A	12 months	1 month
II	Busy Urban Areas	N/A	12 months	3 months
III	Other Urban and Busy Rural	N/A	3 years	6 months
IV	Little Used Rural	N/A	5 years	1 year
Cycleways				
I	Part of Carriageway	As for Roads	As for Roads	As for Roads
II	Remote from Carriageway - Surfaced	N/A	1 year	6 months

Note:

1. Where inspections are deemed N/A this assumes that any necessary information is collected with other surveys.

2. Where there are long intervals between safety inspections, action will be necessary immediately following any public complaints.

CHAPTER 2. DESIGN AND CONSTRUCTION

CONTENTS

CHAPTER 2. DESIGN AND CONSTRUCTION

SUMMARY

Whilst footways in practice generally tend to be detailed rather than designed, this approach is slowly undergoing change with specifiers tending more and more to consider seriously aesthetic as well as structural design, with a view to minimising damage, whole life costs and public liability claims.

This chapter considers the broad areas of geometric, structural and other miscellaneous factors in footway design with due regard and cross reference to the code of practice issued under the New Roads and Street Works Act entitled Specification for the Reinstatement of Openings in Highways (DOT et al 1992). The miscellaneous design factors are covered under the headings of surfacing and foundation materials, kerbing, drainage, weed control, waterproofing and vehicular crossings. The chapter also deals with footway construction aspects in terms of traffic safety and control, compaction, material delivery and laying temperatures and methods of working in a practical scenario. An attempt is made, where possible, to draw on the results of a survey of a small but representative sample of highway authorities to set out and highlight current and best practice respectively.

There is a need to collate the few available references together with empirical test results, existing practical knowledge and experience to formulate a rationalised design and construction guide for footways. Further investigation, research and development is necessary in order to ensure completeness of the document and give it a good utility value. Specific regard needs to be paid to rationalising the choice of materials and to factors affecting long-term maintenance and whole life costs.

One specific area of research to be considered is that of the comparison of performance models to determine those most appropriate for use in footway design. These models need to be tested for sensitivity to parameters such as traffic loading, foundation strengths and construction type.

1. INTRODUCTION

The objective of a footway is to provide a safe walking path for pedestrians, segregated from traffic, free from obstructions, depressions, trips, loose surface and standing water.

Whilst footways in practice generally tend to be detailed rather than designed, this approach is slowly undergoing change with specifiers tending more and more to consider seriously the aesthetic as well as structural design of footways with a view to minimising damage, whole life costs and public liability claims. The concepts of customer care and user friendliness are increasing in significance and this is beginning to be reflected in both the choice of design parameters and materials as well as the serious consideration given to the pedestrian user during construction stage. The philosophy behind the New Road and Street Works Act (1991) together with the new Chapter 8 of the Traffic Signs Manual is a classic indication of the present day concern given to minimising disruption, and according safety to the pedestrian highway user during the course of on-going works as well as the permanent state.

This Chapter considers the broad areas of geometric, structural and other miscellaneous factors for footway design which can be applied on the whole to the provision of new as well as the rehabilitation of existing footways. The major constraints, however, in the rehabilitation process is the ability to upgrade or vary the existing geometry.

An outline is given of the Lilley method for footways expected to suffer frequent overrun by lorries loading and unloading.

Whilst the documents listed below exist as a basis for the design of footways, not any single one deals completely with all aspects relating to footways. A dire need therefore exists for an all embracing designer's handbook on the subject design of footway constructions.

(a) Roads in Urban Areas

(b) Roads in Rural Areas

(c) Design Guide for Footway Construction - NPKA Publication

(d) TRRL - Road Note 29

(e) TRRL - Laboratory Report LR 1132 - The structural design of bituminous pavements

2. GEOMETRIC DESIGN

Pearson's paper on the 'History and Development of the Physical Requirements of Footways' (BCA Seminar, December 1991) lists the preferred values for Footway Design Standards in general very comprehensively. They are reproduced here for general reference, bearing in mind the fact that variances to these values are being used by different highway authorities in practice.

The general trend for geometric design considerations pivots around a consensus width of 1.8m and a crossfall of 1 in 40 (2.5 per cent) with most authorities possessing a standard detail against which to work.

2.1 FOOTWAY DESIGN STANDARDS - GENERAL

(a) Surfacing Materials - to enhance the environment, resist local point loads and achieve minimum whole life cycle costs.

(b) Construction - to be capable of accepting overrun from commercial vehicles or physically prevent access of vehicles and achieve minimum whole life cycle costs.

(c) Widths:

Minimum	2.0m
At Bus Stops	3.0m
Adjacent to Shops	4.5m

(d) Gradients - whole related to site topography, the following are preferred:

Longitudinal minimum	1 in 100	(1 per cent)
Crossfall maximum	1 in 40	(2.5 per cent)
Minimum	1 in 80	(1.25 per cent)
Ramps preferred	1 in 20	(5 per cent)
Maximum	1 in 15	(6.7 per cent)

(e) Crossings - dropped crossings to be provided at all radius points. At controlled crossing points, a textured and colour differentiated surface should be used.

(f) Channel - at all crossing points a channel block should be used in conjunction with a bullnosed centre stone kerb. The vertical rise at the kerb should not be greater than 10mm.

(g) Bollards - to be not less than 1m high and have colour differentiation banding on top one third, placed immediately behind a 300mm wide kerb.

(h) Surface texture - not greater than 3mm.

(i) Skidding resistance - coefficient of friction >0.5.

(j) Drainage - positive system to be provided capable of accepting rainfall at a rate of 50mm/h. Gratings to be flushed with surface, non-slip, having openings not greater than 20mm and set perpendicular to the line of pedestrian flow.

(k) Lighting

Crime Risk Category	Surface Luminosity (lux)	
	Average	Minimum
High	10.0	5.0
Average - Low	6.0	2.5
Very Low	3.5	1.0

(l) Street Furniture - all sign poles and lighting columns should be sited at the back of the footway.

3. STRUCTURAL DESIGN

Although the survey results indicate that none of the respondents include structural analysis in their procedure for the design of new or rehabilitation of existing footways, it is important that accepted methods of analysis are set out under this heading in order to stress the importance of adopting this approach for the purpose of determination of the foundation layer thickness. Presently available guidance on structural design essentially deals with modular footways; bituminous footway construction thickness being widely specified using the parameters of custom, practice and experience.

It is, however, interesting to note that the Specification for the Reinstatement of Openings in Highways (DOT et al 1992) (hereafter referred to as the HAUC Specification) stipulates an overall surfacing thickness of 80mm for flexible footways; 50mm for the base and 30mm for the wearing course layers respectively. The question of surfacing thickness therefore needs to be addressed, with a view to perhaps aiming for a consistent depth of 80mm at design stage, in common with the requirements of the HAUC Specification.

The above document, however, requires sub-base to be reinstated to existing thickness between the maximum and minimum values of 150mm and 100mm respectively. Any analytical considerations for foundation design will therefore be constrained by this requirement.

3.1 THE NPKA GUIDE FOR DESIGN OF FOOTWAYS

The NPKA Design Guide (1991) provides a design method for situations where a footway is expected to suffer overrun from commercial vehicles and is intended to prevent the subgrade being over-stressed and therefore deformed excessively, while also ensuring that the flags are no over-stressed.

The fundamental principle of this Design Guide is the evaluation of the thickness and type of sub-base to be used beneath the flags. This is to ensure that the load induced stress in either the flag or subgrade is not exceeded and the pavement will then be serviceable without major maintenance. Certain assumptions are made as follows:

a) The flags used comply with the requirements of BS7263 (1990) and have a minimum tensile stress in bending of 4.8N/mm^2. To allow for the effect of repeated loadings maximum allowable design stress is taken as 3.15N/mm^2.

(b) There is at least a minimum sub-base thickness of 100mm.

(c) The sub-base will be Type 1, Type 2 or CBM.

(d) One movement of a heavy goods vehicle HGV is normally taken to be equivalent to one standard axle loading. If the actual types of vehicle are known it allows for a more reliable estimate, using values given in Table 2 of the Guide.

Relevant sections from the NPKA Design Guide are reproduced in Appendix 2.A giving the design procedure, design information, practical consideration and details required together with the relevant graphs.

3.2 THE LILLEY METHOD

3.2.1 Traffic

Some footways, such as those outside certain shops like a furniture retailer, can be expected to suffer lorries parking frequently, for loading and unloading. This parking needs to be translated into numbers of standard axle loads per year. Even in a heavily trafficked urban area it is improbable that any particular part of a footway will suffer more than about five commercial vehicle movements per working day. While a vehicle is partially parked on a footway there can be no further loading, so although the count appears low it is considered reasonable. If more reliable data are available this could be used for the initial calculation of traffic. The five movements per day corresponds to some 3,000 to 4,000 standard axles per year but as these are likely to be channelised, it is prudent to multiply this estimate by three. It is also unlikely that there will be a significant increase of vehicle flow with time. Therefore, the total number of movements of standard axles over a 20 year period is not likely to exceed 0.25 million. This calculation is not intended to be definitive but as an indication of the traffic likely to arise.

3.2.2 Subgrade Bearing Value

In an urban area the material beneath any existing footway is likely to be very variable, consisting of various random materials and for this reason it is not likely than any normal site investigations could reliably foretell the subgrade soil type. The installation of various services beneath the footway will add to this variability and, in the author's opinion, there is therefore, no merit in trying to define its CBR with precision. It is suggested that subgrades will be those made up of non-plastic sands, gravels or rocks, while all others are considered as 'weak'. For design purposes the 'good' subgrades should be treated as having a CBR value of 20 per cent, while 'weak' subgrades have a CBR of 2 per cent.

TRRL Laboratory Report LR1132 "The structural design of bituminous roads", the most widely used design document, requires allowance to be made for damage done to subgrades both by exposure to the weather and construction traffic. It is improbable that a significant amount of footway construction traffic would travel over a footway subgrade, or that it would be exposed for any long period. It is, therefore, suggested that the thickness of any sub-base should be selected using Road Note 29, which shows that for traffic of 0.25 msa and subgrades with a 2 per cent CBR, a minimum sub-base thickness of 400mm is required, while those with a CBR of 20 per cent or more, no sub-base is required. This is suggested as a simple and realistic procedure for selecting the sub-base thickness for footways to be surfaced with either flags or blocks.

This method of design, though simple to adopt is at total variance with the requirements of the HAUC Specification as well as current practice. None of the authorities surveyed adopt either a 400mm thick layer of sub-base or leave it out altogether in footways.

3.3 Northern Ireland DOE Footway Trials

The Research and General Section of the Department of Environment Roads Service of Northern Ireland carried out footway trials during 1987 and 1988 to determine the effects of vehicle overrun on various types of modular construction. Following these trials, the following recommendations were made to provide a satisfactory and cost effective solution to footways subjected to vehicle overrun. Full details of the trials are contained in Report TR39 (1987) of the Northern Ireland Department of the Environment Roads Service. Following these trials, the following recommendations were made to provide a satisfactory and cost effective solution to footways subjected to vehicle overrun:

(a) 60 x 900 x 600mm and 50 x 600 x 600mm HC concrete flags should not be laid at locations where they may be subjected to vehicle overrun.

(b) Where flagged footways may be required to withstand vehicle overrun then the thickness of the flags specified should be at least 65mm and if frequent or, particularly heavy vehicle overrun is anticipated then 75mm thick flags should be used. The flags should be laid on a well compacted type 3 granular base and bedded on sand.

(c) Smaller element concrete flags e.g. 300 x 300 x 75mm and 400 x 400 x 75mm perform better under vehicle overrun conditions than larger flags of similar thickness.

(d) Footway trials have shown that small element flags when laid with a close 3mm joint which is then filled with sand perform satisfactorily under vehicle overrun conditions.

(e) Concrete block paviors laid on 50mm deep sand bedding and 100mm Type 3 granular base give a satisfactory performance under vehicle overrun conditions.

(f) When flags require to be replaced or re-laid care must be taken to ensure that the supporting base materials have been properly compacted before laying.

(g) In areas where flagged footways are repeatedly destroyed by vehicle overrun, a surface concrete finish 100mm thick or 25mm hot rolled asphalt on 50mm of dense bitumen macadam basecourse flexible construction, is considered to the most cost-effective solution to the problem.

Where wide footways are subjected to vehicle overrun along the kerbline, it is considered appropriate to construct a 1.0m width of the footway immediately adjacent to the carriageway to a specification which will resist the damaging effects of the vehicle overrun. The remainder of the footway may be constructed to a less exacting specification.

At footway locations subjected to vehicle overrun and where overrun is to be positively deterred then consideration should be given to increasing the kerb height above the road channel to 125mm if at all possible.

The advice given by the Roads Service to their Divisional Road Managers, however, is to opt for bituminous construction; the recommendations from the trials being for locations where this is not possible for aesthetic and other reasons.

4. SURFACING MATERIAL STIPULATIONS

4.1 FLEXIBLE FOOTWAYS

There is a wide range of bituminous wearing course materials presently available in the specification, although the survey data indicates that fine graded, medium graded, dense and rolled asphalt wearing course types are commonly used with thicknesses ranging from 15mm to 25mm.

In practice difficulties exist with bituminous surfacing materials in achieving the required compaction, temperature retention and surface regularity. The choice in the specification, therefore, needs to be narrowed to those materials which have proved capable of giving a good finished product under the limitations and constraints of practical construction methods. Respondents to the survey identified fine cold, hot rolled and mastic asphalts as problem materials.

The HAUC Specification has correctly narrowed the choice of wearing course for reinstatements in flexible footways to hot rolled asphalt, dense macadam and permanent cold lay materials with a 30mm thickness stipulation. Overall design consideration will need to give due regard and perhaps dovetail with the requirements of the HAUC Specification, albeit more experience and trials on the performance and durability of permanent cold-lay materials will need to be generated.

Almost all the survey respondents indicated the use of dense macadam as the basecourse material in flexible footways with a thickness range of 35mm to 50mm. In this respect, a broad consistency of approach prevails within the highway authorities as well as with the requirements of the HAUC Specification.

4.2 MODULAR FOOTWAYS

Here also, a wide variety of proprietary products in a multitude of colours and types are available for use within the constraints of the British Standards requirements, and the survey results indicate that a wide variety are indeed in use in practice. Although opinion of the respondents on the need to narrow the specification range is divided, difficulties of matching each individual choice at a later date are bound to arise due to non-availability of type and colour. This will be particularly highlighted when small scale replacements are necessary such as those of statutory undertaker works. The HAUC Specification has identified this problem and stipulates colour, shape and size as the order of criteria to be used for choice of acceptable replacements when identical replacements are no longer available.

The sand infill to the gaps between the paviour blocks exhibits the following problems in construction and serviceability at present:

(a) Allows water ingress into the sub-base and subgrade resulting in contamination and loss of foundation strength until self-sealing has occurred.

(b) Sand is difficult to retain within the gaps where downpipes and faulty guttering to properties prevail.

(c) Mechanical sweepers have a tendency to suck out the sand infill and subsequent sweeping cycles can lead to freed blocks being lifted by the suction process. This occurs more specifically in pedestrianised areas.

In an article published in the Highways and Transportation Journal (1991), J A Emery examines the most effective means of preventing erosion problems in block paving and concludes the most effective material to be a specially formulated pre-polymer which retains elasticity after curing and is thus able to sustain the essential flexible nature of the block paving surface. Emery's conclusions were drawn, however, on the basis of trials at Luton Airport for stabilisation of jointing sand removed by the action of jet engine blast. In a less harsher footway environment, however, cementitious material such as lime dust, Pulverised Fuel Aggregate (PFA) and sand-bentonite mixture need to be further investigated for durability and performance even though Emery was unsuccessful with these materials under the jet engine blast loading.

4.3 IN-SITU CONCRETE

Most of the authorities canvassed do not specify or use in-situ concrete in general as a surfacing material except in areas of vehicle overrun, vehicular crossings and heavy duty crossings. Practical difficulties exist in the use of concrete in terms of achieving the required finish in a maintenance operation as well as the need to undertake large scale renewals due to difficulty of effective localised patching. Access to services is also difficult through reinforced concrete.

5. FOUNDATION MATERIAL STIPULATIONS

It is plainly evident from the results of the survey that most authorities tend to opt for the use of Type 1 or 2 sub-base to depths of 100mm or 150mm for footway foundations in general with a 25mm mortar or sand bed thickness as appropriate for modular footways. Whilst this consensus correlates with the stipulations of the HAUC Specification, the process of structural design is altogether circumvented and possible damage by vehicle overrun overlooked.

Whereas the process of undertaking structural design may be considered to be onerous and impractical for the rehabilitation of each individual footway, further research may be able to establish a semi-standardised approach to the determination of foundation layer thickness.

6. KERB STIPULATIONS

Kerbing is an expensive item in relation to the cost of construction of the walking surface so that bedding and backing details require careful examination and rationalisation in order to ensure durability, minimum maintenance and low whole life costs.

In this regard, it is not uncommon to see the backing concrete left too high at construction stage, such that enough depth is not available to accommodate the footpath construction thickness behind the kerbline. If the back of kerbing is supported by the footway construction thickness, most respondents agree that the backing detail should be nationally agreed to a lesser requirement in order to eliminate this problem without necessarily reducing the level of backing restraint.

Responses from a majority of the authorities surveyed indicate a common use of half batter and splayed kerbs with upstand ranging from 100mm to 130mm. In answer to a specific question, it was commonly felt by the surveyed authorities that an increase of the upstand to 150mm would not be acceptable for reasons of decreased kerbing stability and difficulty of usage by pedestrians. In addition, restrictions on kerb mounting on roads would inherently narrow carriageway widths.

7. DRAINAGE STIPULATIONS

Drainage of a footway surface is undertaken using the following options:

(a) Dished channels across width of footway;

(b) Footway gullies;

(c) Offlet weir kerbs; and

(d) Alexander drains (Safeti kerbs).

Consensus of opinion from the surveyed authorities is to try to avoid using any of the above options for reasons of pedestrian safety and difficulties of maintenance. In practice, however, dished channels tend to be most widely used with the other options following in the order listed above.

The general concern expressed about the last three options was that regular de-silting is necessary for effective functioning of the facility.

8. WEED CONTROL STIPULATIONS

Vegetation growth is a major problem in modular construction particularly due to a combination of inherent and wind-carried seed growth. Weed control, therefore, forms an important and significant aspect of design (as well as maintenance).

A preventative weed control requirement helps to minimise inherent growth and thus reduce cyclic weed killing expenditure during the lifetime of a footway.

Notwithstanding the above, it is practically impossible to eliminate weed growth and most authorities programme chemical application to footway surfaces on an annual or bi-annual basis as a curative measure. Recent movement towards environmentally friendly materials is rendering such cyclic operations increasingly ineffective and further consideration and research needs to be undertaken to attain higher levels of effectiveness in this operation.

9. WATERPROOFING STIPULATIONS

Where a footway is located above basement accommodation to properties and is of modular construction, water ingress through the joints will cause damp penetration into the property until self-sealing to the modular joints has effectively been achieved.

Whilst there is no obligation on a highway authority to make the footway surface waterproof, the legal position in a rehabilitation scenario is not conclusive with one school of thought contending that, if water ingress is experienced for the first time after the surface renewal, the highway authority may be liable.

In practice, therefore, with only nominal additional costs, the placement of a damp-proof membrane between the sand and the sub-base layers eliminates any problems created by the unsealed joints and probable disturbance of the sealed subgrade material; the operation being undertaken on a good neighbourly basis.

10. VEHICULAR CROSSINGS CONSIDERATIONS

Whereas structural design is not undertaken for determination of construction thickness in vehicular crossings according to the survey results, a wide range of standard thicknesses are currently being adopted by authorities with and without a roadbase layer. The most common approach appears to be an overall thickness of 230mm without use of a roadbase layer and with compensating variations in the sub-base, base and wearing course layer thicknesses in domestic crossings.

With increasing level of car ownership, and for security reasons, occupiers of the older housing stock are striving to keep their vehicles within the curtilage of their properties rather than rely on exposed kerbside parking overnight. This has led to the need for new crossings across existing footways which have to be constructed to the specification requirements of the highway authority.

In response to a question on the incidence of illegal vehicular crossings, the results of the survey were broadly equally divided into those with high and those with low levels of incidence respectively. One authority, with a very large magnitude of this problem, is applying a procedure under Section 184 of the Highways Act (1980) to deal with such unauthorised crossings.

Where the construction of such crossings is managed by the highway authorities, the majority of the survey respondents did not perceive any problems with compliance of the specification and other requirements.

11. CONSTRUCTION

The Department of Transport Standing Committee on Highway Management (SCHM) has recently published 'Preferred Method No. 9 on Footway Construction' to cover the construction and reconstruction of the four types of footways that are most used throughout the UK today as listed below:

(a) Bituminous macadam;

(b) Pre-cast concrete paving;

(c) Natural stone paving; and

(d) Small element paving.

Preferred Method No. 9 incorporates flow charts and method statements which cover the whole range of requirements likely to be encountered in either an urban or rural situation. In conjunction with Preferred Method Nos. 2 and 5 on Kerb

Laying and Natural Stone Kerb Laying respectively, the addition of Preferred Method No. 9 enables all features of footway construction and rehabilitation to be covered.

In practice, the rehabilitation of existing footways poses far greater problems than the construction of new footways generally. This is given further consideration in the various aspects of construction dealt with below.

11.1 TRAFFIC SAFETY AND CONTROL

The latest edition of Chapter 8 of the Traffic Signs Manual adequately details the need to provide alternative or diversionary footways and adequate temporary access to properties to safeguard the pedestrian highway user, with particular regard to the needs of the disabled and partially sighted people. The main difficulty in practice appears to be that of implementation and compliance rather than lack of written criteria. In the commercial arena, there is always a tendency to consider cost at the expense of safety requirements. Practical difficulties of implementation and compliance will only be overcome, therefore, if a consistent and standardised approach is adopted nationally by all client authorities. This will create a 'level playing field' for competing contractors and hence bring about a general improvement in standards of implementation and compliance.

11.2 CONSTRAINTS ON LENGTHS OF EXISTING FOOTWAY AND KERBING TO BE TAKEN UP

The maximum length of footway and kerbing that a contractor is permitted to take up at any one time is an important factor when rehabilitation is being undertaken. This aspect of the method of working is instrumental in determining the traffic safety and control requirements and in enabling a good longitudinal alignment of the kerbline to be achieved.

Present practice generally requires the adoption of a sensible approach based on the location of the works. In order to complement the requirement of Chapter 8 of the Traffic Signs Manual, it may be worthwhile considering the production of general guidelines under the following headings:

Town centres;

Urban areas;

Residential areas; and

Rural areas.

Where both the footway surface and the existing kerbing are to be renewed, respondents to the survey were almost equally divided on the question of whether the existing kerbing should be taken up as a separate operation prior to excavation of the footway surface. If kerbing is taken up and renewed separately in advance of the footway, the facility of a partial footway width is available for pedestrian use, allowing a relaxation in the constraint on length that can be taken up, thus enabling a good longitudinal alignment of the replacement kerbs to be achieved.

In a rehabilitation scenario, factors of existing width, levels of the new kerbing, location of the footway and proximity of street furniture and statutory undertakers' apparatus have to be taken into account in deciding on the method of excavation.

11.3 COMPACTION CONSIDERATION

As a practical matter, achievement of the necessary compaction levels in footway construction is most difficult because of:

(a) Proximity of street furniture, boundary walls, hedge overgrowth and other such obstructions.

(b) The need to safeguard existing kerbing when dealing with foundation layers at the kerb edge.

(c) The need to safeguard existing undertakers' apparatus when working on foundation layers, and

(d) Use of pedestrian rollers.

A very large majority of the survey respondents were able to confirm that factors in (a) above were significant contributors to difficulties of achieving proper compaction on the footway construction thickness materials. The survey results also indicate a common use of pedestrian rollers for compaction in footways. The existence of undertakers' apparatus, however, is not considered to be a problem by a majority of the survey respondents.

In the light of the above, investigation/research is needed to develop a tool to achieve adequate compaction in such restrictive conditions.

11.4 MATERIAL DELIVERY AND LAYING TEMPERATURE CONSIDERATIONS

In the rehabilitation of existing footways, due to the generally small scale and geographical diversity of locations in maintenance operations, difficulties are invariably experienced in maintaining the material temperatures to comply with the requirements of the specification. Also, for footway construction works in general, at wearing course level, small quantities of bituminous material cover large surface areas because of the relatively thin layer. During laying operations, therefore, it is not uncommon for temperature losses to occur resulting in a substandard material in terms of laying temperature requirements. This results in laying and compaction problems and compounds the inherent difficulties of compaction in footways as discussed in section 11.3 above. Almost two-thirds of the survey respondents agreed that a method specification stipulating the use of a hot box should be considered to overcome this very significant problem.

It is perhaps pertinent to note that in a maintenance scenario, the smallness of scale and large distances between operations results in a reduced sampling and testing regime compared to normal practice on a major construction site. It is hoped that with the advent of Quality Assurance, this problem will be alleviated.

12. CONCLUSIONS

This approach to footway design and construction is slowly changing with specifiers considering the aesthetic as well as structural design to minimise damage, reduce whole life costs and public liability claims.

There is a need to relate existing practical knowledge and experience, published research and empirical test results to formulate a rationalised design and construction guide for footways.

The choice of materials needs to be rationalised to factors affecting long-term maintenance and whole life costs.

Performance models, capable of dealing with traffic loading, foundation strengths and construction type are required for use in footway design.

APPENDIX 2.A

Extracts from the Guide for the Design of Footways - National Paving and Kerb Association (NPKA) 1991

Practical Considerations

In this design method, it is necessary to determine by calculation, the required thickness of the sub-base, to prevent both over-stressing of the flag or the subgrade. The thicker of the two values should be used to avoid premature pavement failure by either flag cracking or the deformation of the underlying layers.

The following assumptions regarding the laying procedures have been made:

(a) The bedding sand complies with grade C or M of BS882.

(b) The sand thickness is 25mm thick.

(c) The moisture content of sand is approximately 5 per cent - 7 per cent.

(d) The joints are filled with sand complying with grade F of BS882.

(e) The joint widths are between 2mm - 4mm.

(f) Laying complies with the procedures outlined in BS7263: Part 3 and the NPKA Data Sheets.

(g) The minimum thickness of sub-base material is 100mm.

Details Required

The following information is essential for design procedure:

(a) Type and number of heavy goods vehicles (HGV) using the area. A conservative assumption has been made for the design that one repetition of a HGV is equal to one standard axle. Actual figures can be obtained from Table 2 below.

(b) CBR of the subgrade, if values are not available then Table 3 below can be used as a guide.

(c) The design life of 20 years is most frequently used.

Other information which may be specified at the initial design stage is the size of the paving flag and the sub-base type.

TABLE 1

Average Number of Heavy Goods Vehicles

LOCATION	VEHICLE/DAY
Residential	1
Local Shops	5
Shopping Area	10
Precincts	20

The standard relationship between commercial vehicles and standard axles according to TRRL Supplementary Report SR787 (1982) is shown in the Table 2 below.

TABLE 2

Commercial Vehicles and Standard Axles

VEHICLE TYPE	STANDARD AXLES
2 axle rigid	0.34
3 axle rigid	1.70
4 axle	2.60

If laboratory CBR values are not available then the following Table may be used as a guide to evaluate the equivalent CBR values, the values given have been interpreted from TRRL Laboratory Report LR1132.

TABLE 3

Typical Soil Characteristics

TYPE OF SOIL	PLASTICITY INDEX	CBR
Heavy Clay	70	2
	60	2
	50	2
	40	2.5
Silty Clay	30	3
Sandy Clay	10	5
Sand (poor graded)	-	20
Sand (well graded)	-	40
Sandy Gravel	-	60

When the majority of overrun is from vehicles having two axles it is recommended that one repetition is equal to one standard axle. This will occur when the ratio of two axle vehicles to three axle vehicles are in the ratio of 3:2.

Design Information

The principle of this design is to determine the stress in the flag and subgrade by calculation to reduce this stress to the allowable level. The figures in this publication have been developed from measured data to avoid working from first principles.

Figure 1 represents the sub-base thickness design to prevent over-stressing of the flag types 450 x 450 x 70mm and 400 x 400 x 65mm. This has been calculated using a maximum stress value of 3.15 N/mm^2 which was developed in the flag due to loading, the British Standard stress at failure of 4.8 N/mm^2 and the Portland Cement Association Fatigue Model Stress Factor. For paving flag type 300 x 300 x 60mm, the minimum thickness required to prevent over-stressing of the flag is 100 mm of sub-base.

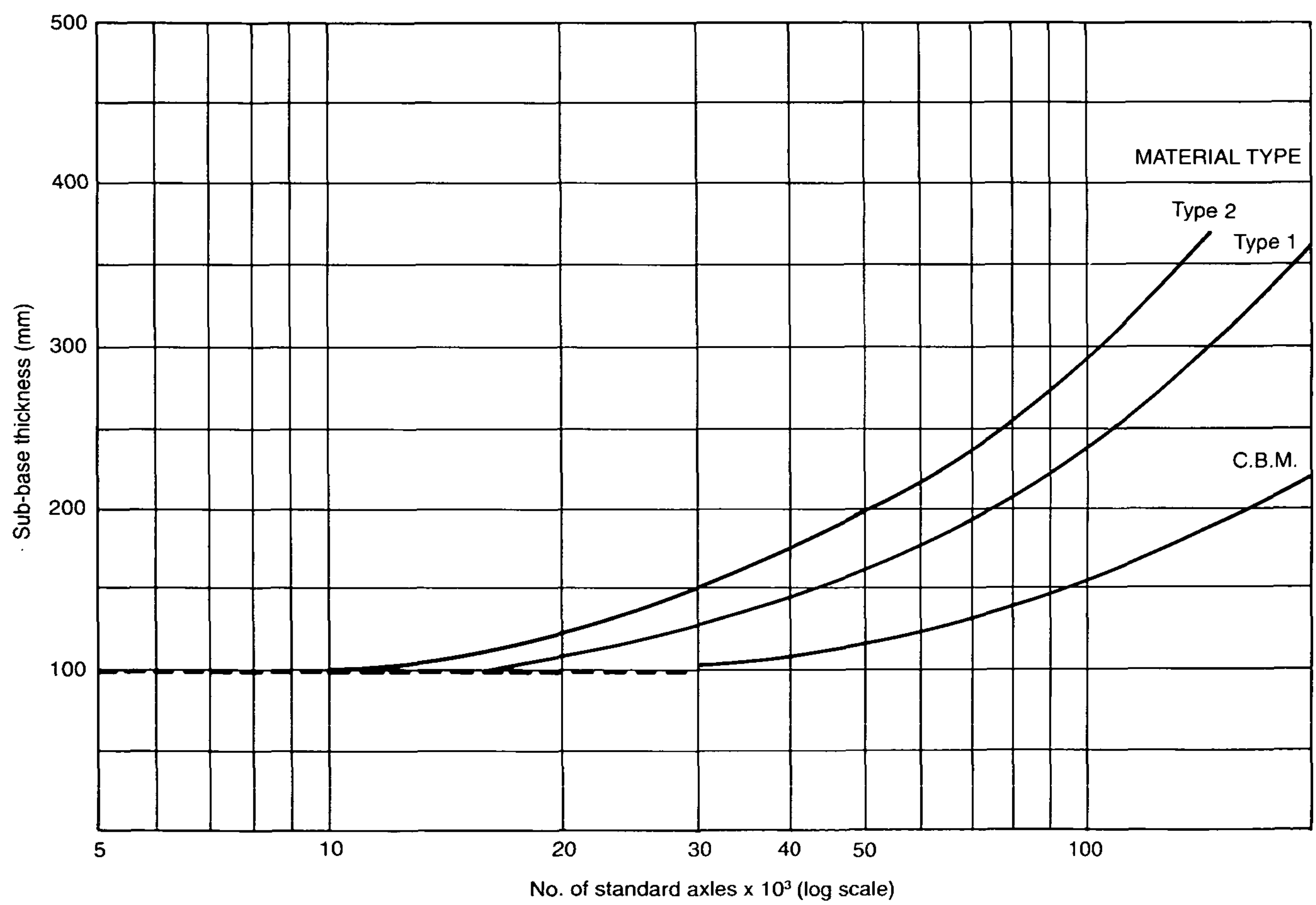
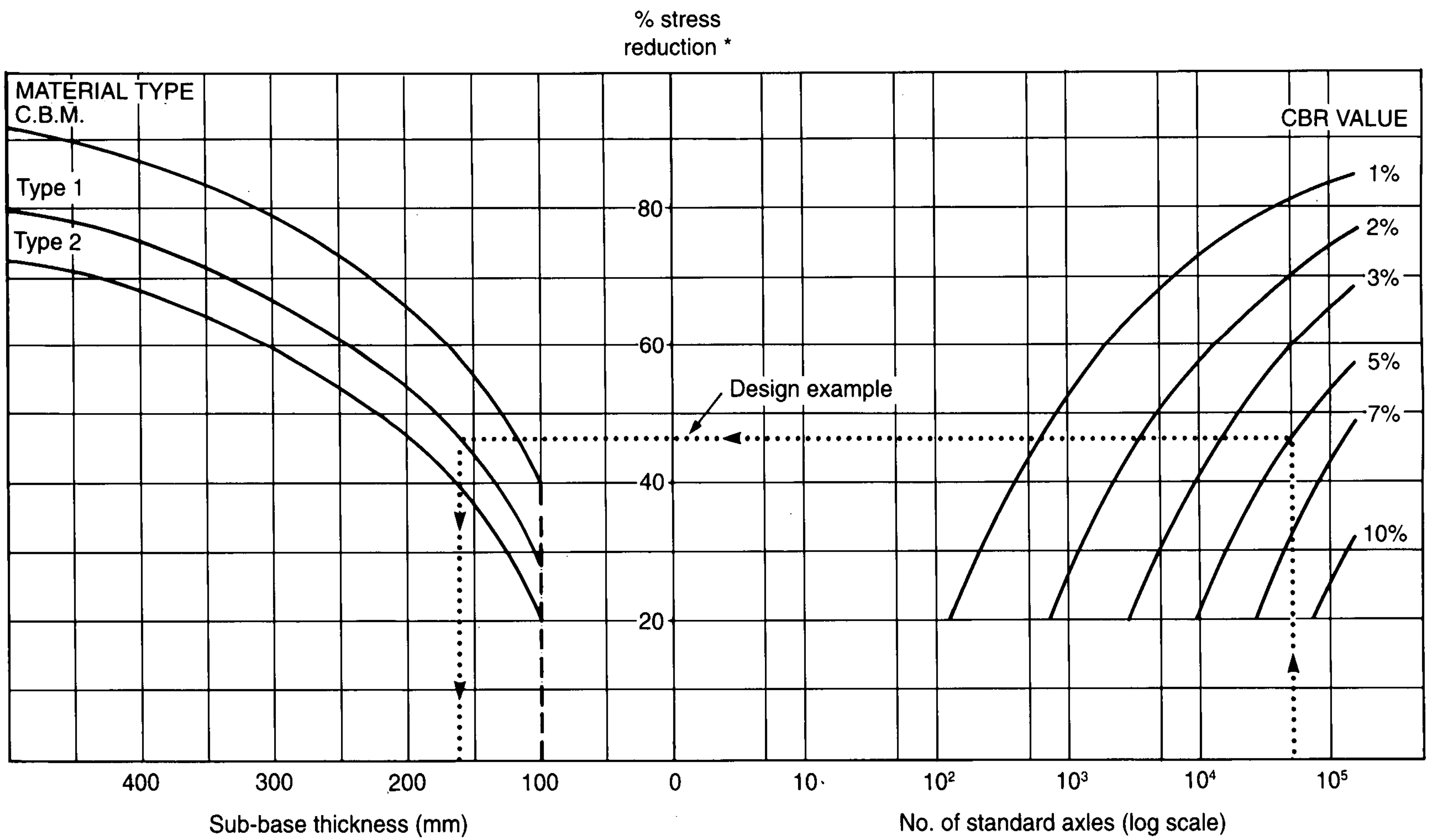


Fig. 1. Sub-base Thicknesses

Figure 2 shows the influence of load repetitions, sub-base thickness, sub-base type and the percentage stress reduction for subgrade failure, related to the subgrade CBR for flag types 450 x 450 x 70mm and 400 x 400 x 65mm.

(For paving flag types 450 x 450 x 70mm & 400 x 400 x 65mm)



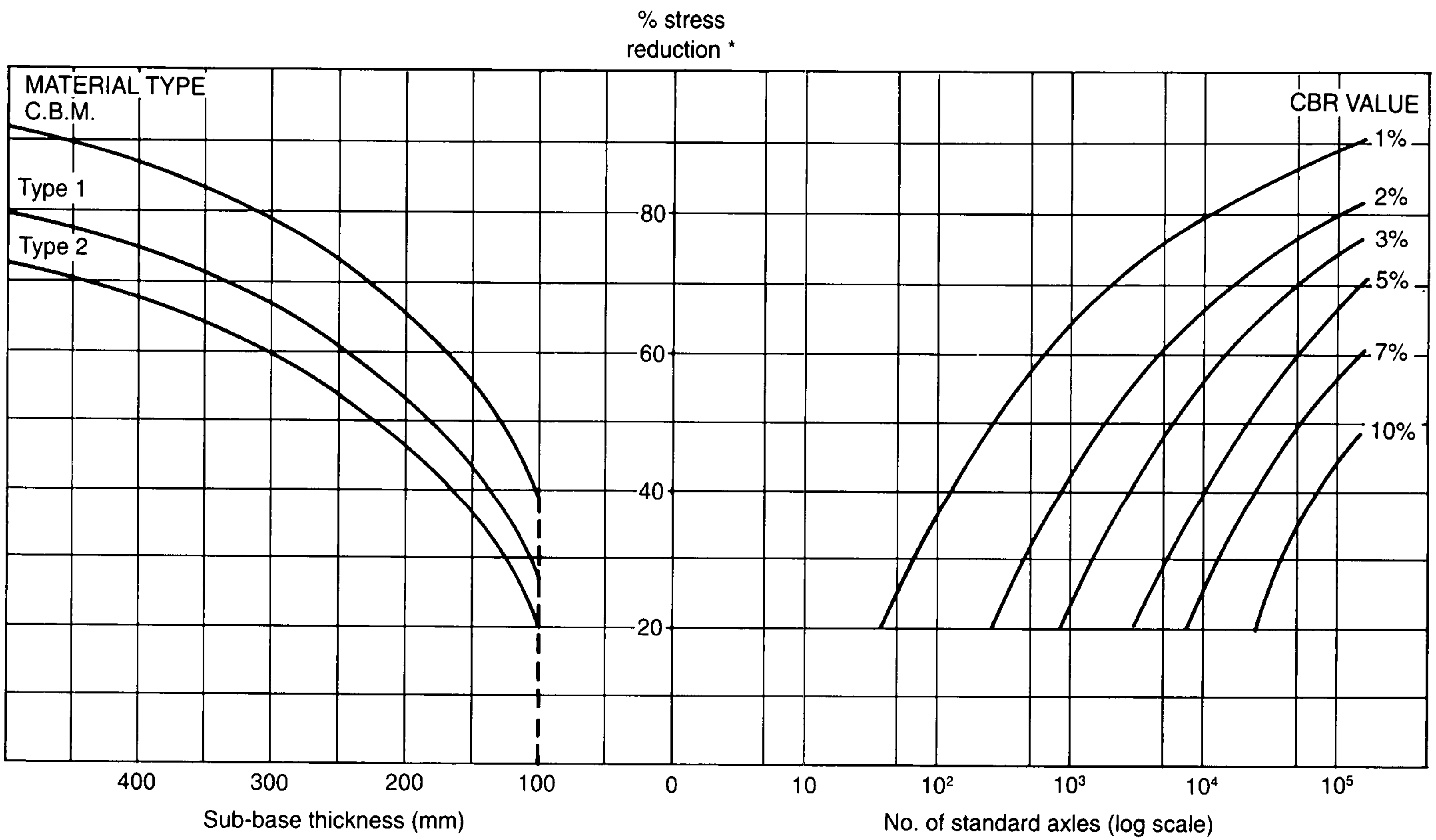
* % stress reduction axis is only used for first principle design

Fig. 2. Load Repetitions, Sub-base Thickness and Type

(For 450 x 450 x 70mm and 400 x 400 x 65mm)

Figure 3 relates to flag type 300 x 300 x 60mm.

(For paving flag types 300 x 300 x 60mm)



* % stress reduction axis is only used for first principle design

Fig. 3. Load Repetitions, Sub-base Thickness and Type

(For 300 x 300 x 60mm)

Design Procedure

For Paving Flag Stress

Calculate the number of expected repetitions during the design life of the pavement. Read off the sub-base thickness from Figure 1, depending upon sub-base type. Draw a vertical line up from the number of repetitions to the intersection with the sub-base material curve. Then project this horizontally to the sub-base thickness axis. This gives the required sub-base thickness that will ensure the flag is not over-stressed.

For Subgrade Stress

Select either in Figure 2 or Figure 3 depending upon the flag type. Using the same repetition value as above, project a line vertically to the intersection with the appropriate subgrade CBR curves. Project a horizontal line to the stress reduction axis and continue until it reaches the appropriate sub-base type curves. Then project a line vertically down onto the sub-base thickness axis and record this value. The greater sub-base thickness obtained from the graphs in either Figure 1 or Figure 2 or Figure 3 should be adopted.

Overlay

Paving flags are used as an overlay to existing pavements, mainly for pedestrianisation schemes. This use may require a structural design for the proposed overlay depending on the intended use. If vehicles are to use the area then it is necessary to estimate the residual life of the existing pavement in order that the overlay depth needed to give the desired overlay can be determined.

The pavement should be inspected for surface cracking and rutting and an assessment on the residual life in terms of standard axles should be made.

It is suggested that this design method should be followed and then the existing construction compared with values obtained from the design charts.

CHAPTER 3. CAUSES OF FOOTWAY PROBLEMS

CONTENTS

CHAPTER 3. CAUSES OF FOOTWAY PROBLEMS

SUMMARY

In general terms, it was found that 60 per cent of the maintenance budget was spent on planned major maintenance, 10 per cent on preventative maintenance and 30 per cent on non-programmed work.

Responses from County Councils indicate that the following four factors each accounted for about 20 per cent of footway failures:

Poor design and specification

Faulty construction

Abuse

Fair wear and tear.

The Districts and Metropolitan Districts indicated that about 25 per cent of failures were attributable to abuse while poor design and specification and fair wear and tear" each accounted for about 20 per cent. Faulty construction was not perceived as a major problem.

Authorities from both groups expressed concern at increased damage by vegetation following a move away from the use of residual weedkillers.

Eighty per cent of the 30 authorities who responded stated that they would like to see measures taken to reduce vehicle overrun. While 75 per cent felt there was a need for improved design standards and construction methods.

Control and supervision of the utilities was considered to be a significant problem with opinions divided on the effectiveness of the New Roads and Street Works Act 1991.

The average County Council expects to spend about 25 per cent of its structural maintenance budget on footway repairs but this increases to 50 per cent for the District and Metropolitan Districts. Nationally this suggests that over £300 million is spent on footway maintenance every year. Unfortunately survey information suggests that about 33 per cent of this is spent on non-programmed work (patching/local repairs etc.) while only ten per cent is used for preventative maintenance. Very few authorities use accident claim information to target maintenance work or justify budget allocations.

1. INTRODUCTION

Footways developed as a separate identifiable part of the highway when the volume of horsedrawn or motorised traffic became sufficient to displace the pedestrian from the centre of the highway. The initial concept of a purpose built footway was to provide a safe and unobstructed walking surface for pedestrians. Heavily used footways in towns and cities became paved with stone flags or broken stone. A kerb or channel was often provided to afford the pedestrian some additional protection from passing traffic.

However, during the twentieth century the role of the footway has been extended. That part of the highway that was once the sole preserve of the pedestrian is now seen by the utilities as a more accessible and advantageous location for their equipment in preference to the main carriageway. Also with increasing pressure on road space, drivers often find the footway a convenient place on which to park their vehicle.

In recent years the modern concept of the highway dominated by vehicular traffic has been reversed in some areas with the pedestrian being given priority. Many main shopping areas have now been redesigned for the convenience of the pedestrian rather than the motor vehicle. However, in all but a few cases, these pedestrianised highways are still required to carry a substantial element of vehicular traffic.

The increased role of the footway has had a major impact on traditional design and methods of construction. It was once claimed that a well-laid stone flagged footway would last for several centuries with minimal maintenance.

This would be true even today if the footway were subject to pedestrian traffic alone. Clearly this is seldom the case and it is the twentieth century developments in the use of footways that have caused many of the problems that currently exist.

2. CAUSES OF FOOTWAY PROBLEMS

In an attempt to identify and evaluate the various causes of footway problems the sample highway authorities, targeted with the questionnaire, were asked to estimate the percentage of their maintenance budget being spent to rectify faults within the following seven categories:

2.1 POOR DESIGN AND/OR SPECIFICATION

- Inadequate assessment of loading (vehicular traffic) leading to premature failure
- Poor design of associated carriageway, parking facilities etc. leading to increased vehicle overrun
- Poor drainage design
- Inappropriate choice of materials
- Poor design of edge restraints

2.2 FAULTY CONSTRUCTION

- Use of substandard/incorrect materials
- Noncompliance with levels/level tolerances
- Inadequate compaction

2.3 ABUSE

- Poor trench reinstatement by utilities
- Damage by builders/developers

2.4 WEATHERING

- Degradation of bituminous materials
- Surface fretting/spalling due to freeze/thaw cycle
- Subsidence due to subsoil shrinkage

2.5 FAIR WEAR AND TEAR

- Loss of surface texture
- Fretting of wearing course
- Structural failure at end of design life

2.6 DAMAGE BY VEGETATION

- Tree roots/weed infestation
- Moss/lichen growth on surface

2.7 PERCEIVED FAILURE

- Footway is safe and serviceable but surface appearance is unacceptable to general public due to numerous reinstatements and/or use of poorly matching materials for repair work.

It was recognised that few, if any, highway authorities would be readily able to break down their expenditure to this level of detail and answers, therefore, might be intuitive or subjective. However, it was considered that the combined responses would be useful in identifying those areas where the major problems were perceived to exist. Authorities were also asked to detail any other significant problems outside the seven categories listed.

Responses from the County Councils indicated that the following four factors each accounted for about 20 per cent of maintenance expenditure:

(1) Poor design and specification;

(2) Faulty construction;

(3) Abuse; and

(4) Fair wear and tear.

One factor alone was seldom entirely responsible and it was nearly always considered to be a combination of two or more of these principle factors that led to the requirement to undertake maintenance. The aggregated responses from the Metropolitan Districts/District Councils was slightly different indicating that abuse accounted for more than 25 per cent of footway problems while faulty construction only accounted for six per cent. All other factors were very similar to the County Councils. The increase in abuse obviously reflects the higher level of activity of the utilities and developers in the built-up areas. The reduction in faulty construction may possibly indicate that it is easier to provide effective site supervision in compact urban areas as opposed to scattered rural communities.

The following lesser factors accounted for the majority of the remaining 20 per cent of failures for both County Councils and District Councils.

(1) Weathering

(2) Damage by vegetation

(3) Perceived failure

A number of authorities expressed concern about recent changes in weed control policies with a move away from the use of residual weedkillers to more environmentally friendly products and considered that damage due to vegetation might be on the increase as knockdown herbicides are proving less effective.

The following were cited by certain respondents as additional factors leading to deterioration of footways:

i) Loss of kerb face due to carriageway resurfacing

ii) Theft of specialist/decorative surfacing elements

iii) Removal of jointing sand by suction sweepers from small element and block paving

iv) Damage to older surfaces due to imposed load of mechanical cleansing equipment

v) Mining subsidence

3. LIMITATION OF FOOTWAY DAMAGE/DETERIORATION

The sample authorities were asked to state what measures they felt would lead to a reduction in footway damage.

3.1 PREVENTION OR REDUCTION IN VEHICULAR OVERRUN

Approximately 80 per cent of authorities cited prevention or reduction in vehicular overrun as a measure that would reduce footway damage. Suggested means of control fell into four main areas:

(a) National legislation to give highway authorities improved powers to prohibit parking on footways and other areas intended for pedestrian use only.

(b) Improved education of the general public aimed at reducing parking on footways.

(c) Physical prevention by increased kerb heights and greater use of bollards.

(d) Improved highway design and better planning and design of sites adjacent to the highway to reduce the need to park on footways.

3.2 IMPROVED DESIGN AND CONSTRUCTION OF FOOTWAYS

Seventy five per cent of authorities stated that they would like to see improved design and construction standards. Many recognised that effective control of vehicular overrun is impossible in many areas. Therefore, this form of abuse must be accepted and provided for in the design process.

3.3 BETTER CONTROL AND SUPERVISION OF UTILITIES

Thirty three per cent of the respondents stated that a significant amount of damage could be eliminated if there was better control of the utilities. However, opinion was divided regarding the effectiveness of the New Roads and Street Works Act 1991 and the adequacy of the code of practice issued under the Act entitled the Specification for the Reinstatement of Openings in Highways (HAUC Specification).

3.4 UNDERTAKE TIMELY MAINTENANCE

Only three out of the 24 highway authorities who provided answers to this section considered that timely or appropriate preventative maintenance would minimise footway damage. It is, of course, possible that the majority of authorities already believe that they have an acceptable regime for maintenance or do not consider this a major factor in the light of the other principle topics listed.

However, information gathered from the questionnaire regarding the funding of unplanned maintenance work gives a somewhat different impression. Of the 23 authorities who gave a response it appeared that on average some 29 per cent of annual budget was spent on unplanned maintenance, 56 per cent on planned major maintenance and around 17 per cent spent on preventative maintenance. These proportions varied widely from one authority to another, with some authorities not spending at all on planned preventative maintenance, others spent 88 per cent of their budget on planned major maintenance, whilst one spent 53 per cent on unplanned maintenance.

3.5 OTHER FACTORS

(a) Suction sweeper damage - a number of Metropolitan Districts expressed concern at their apparent inability to control the use of suction sweepers on newly laid small element or block paved areas. Advice and guidance on how to improve the stability of jointing materials would be welcome.

(b) Tree root damage - a number of Metropolitan Districts expressed concern on this matter and would like to see greater care in selecting and siting trees in the footway.

4. EXPENDITURE ON FOOTWAY MAINTENANCE

The highway authorities contacted by the Footway Maintenance Working Group were asked to supply information relating to their expenditure on structural maintenance during 1991/92.

Aggregating the replies indicated that the average County Council expects to spend about 25 per cent of its structural maintenance budget on footway repairs while District and Metropolitan Districts spend about 50 per cent. Nationally this indicates that between £300 million and £400 million is spent every year on footway maintenance.

Most authorities indicated that their budgets are needs led in keeping with the advice contained in the LAA Code of

Good Practice (1983). Few, however, seemed to have any rational system for allocating priorities between footways and carriageway works. The decision on any split in the total budget largely remains a political matter for most authorities.

The same authorities were asked to supply, if possible, details on how their footway maintenance budget was shared between the following three headings:

i) Planned major maintenance works - e.g. reconstruction/resurfacing etc.

ii) Planned preventative maintenance works - e.g. slurry sealing/surface dressing/routine minor repairs to modular surfaces etc.

iii) Non-programmed work - e.g. patching/local repairs in response to public complaint or non-feasance inspection.

There was a considerable variation between individual responses but when the results were aggregated there was little difference in the overall situation between County Councils and the District and Metropolitan Councils.

Responses indicated that, in general terms, about 60 per cent of the budget is spent upon planned major maintenance, 10 per cent on preventative maintenance and about 30 per cent on non-programmed work.

Clearly the headings are very broad, and the simple breakdown of cost can only give a guide to the overall situation, but it is perhaps worthwhile to note the large proportion (£100 million plus nationally) that is spent on non-programmed work. In comparison with this, the 10 per cent allocated to preventative maintenance appears meagre.

Of the highway authorities questioned about 30 per cent (9 of the 30) stated that the proportion of the budget allocated to footway maintenance was increasing while about 66 per cent (17 of the 30) claimed that the budget had remained largely unaltered or had shown no discernible trend. Only one authority had experienced a decrease.

It had been hoped to make a comparison between the level of footway expenditure and accident claims. While virtually all highway authorities kept records of claims, few were readily able or willing to supply details and costs for footway claims alone. This appears to be something of an omission since such information could be of great assistance when targeting resources and preparing a justification for maintaining or increasing footway budgets.

However, a limited number of highway authorities had become aware of a serious increase in claims in recent years and had targeted their non-feasance inspections and repair programmes to selected areas, usually slabbed or modular footways in city centres, with a view to reducing claims. Two authorities had achieved major reductions in the number of claims as a result of operating such a policy. Both authorities considered that the dramatic increase in claims had come about due to social factors rather than any change in the level of funds available for maintenance. Other authorities expressed similar concerns citing recent television publicity and one gave an example of a solicitor's advertisement inviting potential customers to use his services to pursue claims for injuries and losses due to falls on footways.

5. CONCLUSIONS

The majority of failures were considered to be due to poor design and specification, abuse and fair wear and tear. Faulty construction was considered to be a problem by the County Councils but not by District and Metropolitan Counties.

Most authorities would like to reduce vehicle overrun and agreed that there was a need for improved design standards and construction methods.

About 30 per cent of the estimated £300 million spent on footway repairs is spent on non-programmed work; only ten per cent of the budget was used for preventative maintenance.

CHAPTER 4. MATERIALS AND REPAIR TECHNIQUES

CONTENTS

CHAPTER 4. MATERIALS AND REPAIR TECHNIQUES

SUMMARY

A potentially confusing range of both British Standard and proprietary materials are available for the construction and maintenance of footways. The selection of bituminous materials for flexible footways with appropriate surface and performance characteristics together with the development of materials that are easy to use and have a good storage life are seen as predominant issues.

Inadequate compaction of bituminous materials results in limitations in serviceability and performance of flexible footways. The performance and evaluation of surface treatments is frequently addressed by requesting guarantees. However, in competitive tenders there is concern that inadequate preparatory work is carried out.

The traditional large paving flag for footway paving is considered vulnerable where vehicle overrun is likely; smaller elemental paving is preferred in these circumstances. The loss of jointing sand in block paving by the use of street cleaning suction sweepers is an apparent problem.

The scope for recycled materials in footways is considerable but at present recycling is confined to reuse of bituminous planings and retread. The performance of materials for footways in both surfacing and base materials is compromised by inadequate quality either by a failure to adequately specify requirements or a failure to ensure that those specification requirements are adhered to.

There is no significant research into the performance of footway surfacings or the effectiveness of recycling techniques. The need to gather performance data in respect of footway surfacings and to identify specific research needs is seen as a vital task. Considerable opportunity is afforded by local authorities by co-ordinating trials of materials and new developments.

1. INTRODUCTION

In the construction of new footways, the essential decision is the selection between a flexible footway construction and that of a rigid paving consisting of either a concrete surfacing or precast products. It was evident from respondents to the questionnaire that, in most highway authorities, there was a trend towards increasing the extent of flexible footways at the expense of rigid construction, with flagged footways being phased out except where aesthetic requirements precluded the use of bituminous materials. Clearly the type of material selected for maintenance is influenced by the nature of the existing construction and its condition. In order to consider suitable materials both for new and maintenance works, it is appropriate to consider footway construction materials under separate headings namely bituminous materials, slurry type surfacings, surface dressing, concrete and precast blocks, flags and setts and sub-base material.

The options to repair footways can broadly be considered in four ways:

- reconstruction using new materials as in new construction;
- use of the same materials to 'inlay' a surfacing;
- the application of a surface treatment; and
- footway material recycling.

The type of repair technique and material is substantially influenced by the suitability or otherwise of existing materials for retention and by any potential vehicle overrun problems. A section on recycled materials and techniques is included in this chapter. The compaction of bituminous and granular materials and the performance of surfacing materials is recognised as being very important in the development of improved materials and repair techniques and these matters are considered separately in this chapter.

A point to be noted from the questionnaire survey of authorities was the plea to minimise the range of products available for footway construction in order to reduce maintenance problems and reduce whole life costs.

2. BITUMINOUS MATERIALS

The survey data showed that an extensive range of bituminous materials, listed in British Standards, were utilised with additional proprietary type macadams scheduled to overcome compaction problems with surfacing materials. In some cases the contractor was offered construction material options but more usually the engineer specified requirements with little or no alternative.

2.1 RANGE OF MATERIALS

There was a wide and confusing variety of options available in the selection of bituminous materials for use as wearing courses and basecourses both for new and maintenance works. The use of dense or medium textured wearing course in bituminous surfacing for footways were the most commonly specified surfacing, although the choice between the two reflected divided opinion in respect of what texture was actually required. The question of surface texture in respect of bituminous footways was dealt with subjectively, although a 6mm dense wearing course was more considered to be appropriate. The application of sealing grit to bituminous wearing courses was carried out by some highway authorities.

2.2 DENSE WEARING COURSE

The reintroduction (1988) of 6mm dense wearing course material into BS4987 was clearly necessary and has ensured a consistency of approach. In terms of binder selection, because of the extent of materials laid by hand, the choice of 200 penetration grade was generally considered appropriate although, some highway authorities insisted on 100 penetration grade. Others allowed the use of 300 penetration grade during winter months. These grades are all included within the British Standard, the latest revision of which proposes 100 or 200 penetration grade as preferred grades. The predominant and preferred material for bases in bituminous material was 20mm Dense Bitumen Macadam using either 100 or 200 penetration grade binders although some highway authorities still specified open textured bases. Roadbases, where specified for crossings and access areas, were virtually without exception Dense Bitumen Macadam.

2.3 FINE GRADED MACADAMS

Fine-graded macadams (formerly fine cold asphalt) and rolled asphalt were less utilised by authorities. Rolled asphalt, except in the case of heavy duty vehicle crossings, was usually of low (15 per cent) or zero coarse aggregate type with 100 penetration grade binder normally being specified to ensure workability and ease of compaction. These materials have shown excellent life performance but also have certain disadvantages. The more fine-textured surfaces were smooth and more slippery in wet conditions and because of the higher bituminous binder content were more expensive to supply. To combat the lack of texture in the rolled asphalt, some highway authorities have applied chippings randomly in the surface. To be effective and visually satisfactory this type of work requires a higher skill level and good control of material temperature, and at present, the performance of reinstatements carried out in macadam was superior. In specifying a rolled asphalt surfacing, a 15/10 type F recipe mix wearing course with a chipped surface was seen as the preferred material, as endorsed in BS594 (1992). Some respondents to the survey commented on poor life performance of fine cold asphalt and sand carpet material.

2.4 SPECIFICATION OF AGGREGATES AND MATERIALS

The specification of aggregates of a minimum polished stone and maximum abrasion values for wearing course is carried out by some highway authorities as are requirements for aggregates to meet criteria defining hardness and durability. Other authorities rely on the term hardstone or the phrase 'hard clean and durable' for aggregate selection. Some consideration and uniformity in the properties and aggregate characteristics for footway bituminous surfacing layers is required.

The selection of bituminous materials with inadequate properties and acceptance of inferior or out-of-specification material (because it is only to be used on a footway) was considered to be a significant problem. When allied to inadequate site control, inadequate layer thickness or inadequate compaction of certain materials/layers it can lead to durability problems. The use of macadams for footway construction using softer grades, cutback or deferred set binders has been common in the past with the ad-hoc addition of fluxing material to assist workability for hand laying. This was perceived as being uncontrolled. Such materials are lively after placing and prone to deformation and damage particularly when trafficked. Specifying harder grades of binder for areas likely to be trafficked can minimise this problem. However, recent evidence would suggest that the use of fluxed material is now more controlled and such materials are used for emergency purposes only. Appropriate specifications drawn up from existing British Standards can address these factors and recommendations can be made for new and maintenance construction materials. The new HAUC Specification has done much to identify appropriate footway construction materials.

2.5 QUALITY

The quality of bituminous material used in footway construction was of considerable concern. Workmanship associated with laying and compaction was highlighted as the main area of concern. Testing to ensure compliance was generally inadequate. Highway authorities have an obligation to ensure that the product supplied meets the specification requirements and more emphasis needs to be placed on ensuring quality. The use of out-of-specification materials or materials with inadequate characteristics for permanent works is totally unacceptable.

2.6 STORAGE LIFE

The development of material with long storage life, easy and ready to use with satisfactory performance criteria is a major issue for footway maintenance. Such materials require modified bituminous or synthetic binders and resins and adhesives. The use of synthetic and modified binders allows material to be coloured and may be cold applied for wearing course thicknesses up to 10mm. Further development is taking place to satisfy the need for long storage life, cold-lay materials. The specification for a suitable cold-lay material requires the formulation of special binders which have satisfactory workability characteristics and can provide a mixture when compacted with adequate durability properties, good surface regularity and resistance to deformation. The HAUC Specification assists with this development. However, it is essential that performance assessment is carried out and that an acceptable consistency is developed. Research is now in progress and it is important that this work is completed quickly and the findings rapidly implemented.

2.7 MASTIC ASPHALT

Mastic asphalt was not thought to be extensively used in the UK except for specialist applications. The application of acrylic chippings into mastic asphalt has also been used. The use by highway authorities of mastic asphalt may be relevant although it was regarded as an expensive option. Where it has been used it also proved difficult to reinstate.

3. SLURRY TYPE SURFACING

From evidence received in the questionnaire survey, there was a considerable range of products in this group which can also be considered to include micro-asphalts. Some difficulty in understanding the function and suitability of these materials, their potential performance, whole life costs and the comparative evaluation of alternative products was apparent. To address these difficulties, highway authorities are seeking performance guarantees based on a subsequent visual inspection usually after a two or three year periods. The success of requesting such guarantees is debatable since in the intervening period, the surfacing has inevitably been abused by the use of vehicular traffic or been excavated by utilities.

3.1 LAYER THICKNESS

Often the use of thin layers as a cosmetic approach is inappropriate. The use of thin veneer slurry surfacing 1.5mm thick has substantially diminished with a trend to the application of 3mm to 6mm layer thicknesses particularly where the footway is likely to be subject to abuse. Some highway authorities remain dissatisfied with 3mm layers and specified only 6mm layers to a manufacturer's specification. Even with 3mm material, the material can be laid too thin when placed on a supply and lay surface coverage basis. The development of more sophisticated treatments have therefore allowed re-profiling of a surface and consequently, there has been a trend to thicker lifts. Inadequate surface texture was another concern with thin lift material and this has encouraged some highway authorities to specify material with a larger nominal size requiring thicker lifts.

Where the footway was in good condition the use of 1.5mm slurry has been considered. The use of a thin film surfacing placed directly on a loose, spalled surface was deprecated.

3.2 FIBRE REINFORCEMENT

Adding fibres to the mix has been suggested to allow build up of the material without subsequent depression. It was also suggested that thicker lifts of up to 50mm could be developed which would be satisfactory for early trafficking by vehicles where previously reconstruction may have been necessary. The use of pre-bagged material blended in on site mixers had helped to improve the quality control of slurry seal materials.

3.3 PREPARATION

With any treatment it is vital that all necessary preparatory works are thoroughly carried out and allowed for in any competitive tender. It was clear from the survey, that there was a difference of opinion; some highway authorities took the view that an inclusive tender required contractors to be responsible and maintain the surface for the guarantee period and as such all surface preparation was their responsibility. The cheapest tender was therefore selected, allowing for only minimal preparation, with consequential adhesion problems and weed growth through the applied surface. Some highway authorities took the view that extensive pre-sweeping was necessary and others that high-pressure water jetting should be carried out to adequately remove fretted material, surface moss and detritus. The trial work of one metropolitan council in the north of England which carried out jet washing prior to application was particularly worthy of note. "Thin slurries laid in 1987 have now worn away but thick slurry surfacings (3 to 5mm) were still performing adequately and were considered to have a life of 8 to 12 years. The practice in this authority is to apply a thin surfacing and subsequently to apply a thick layer after about six years".

3.4 POLYMER MODIFIED BINDERS

Polymer modified binder materials are being developed. The incorporation of rubber latex to improve the viscosity and flexibility of these materials is also being examined. Adhesion problems exist with slurry seals over concrete surfaces. The County Surveyors' Society has developed a standard specification and tender document, although it was evident from the survey that this was little used and knowledge of its existence was limited. Limited research has been undertaken either by the trade or purchasers and there has been minimal recording of the performance of such materials. Acceptance has usually been on the basis of trade name only.

3.5 FUTURE DEVELOPMENT

There is potential for the development of a machine to lay slurry seal on footways although hand laying will always be necessary in many circumstances.

The extent of performance feedback data on slurry surfacings was minimal. At the same time however, highway authorities are constantly conducting trials of new materials and are encouraged to include this on the Roads and Pavements Information Database (RAPID) managed by the MARCH Group.

4. SURFACE DRESSING

The extent to which surface dressing is considered for footway maintenance was limited. Some usage was made for dressing footways between rural communities but use in urban areas had been substantially terminated because footway surface dressing often proved to be a common cause for complaint. Chippings and binders were picked up on footwear and trafficked into homes with subsequent claims for damages. Where K1/70 bitumen emulsion was primarily used, 4/5mm aggregate was common, although one highway authority used 100 second cutback bitumen binder. The surface provided can be highly textured and although good in slippery conditions is potentially more abrasive and could be more harmful to pedestrians when accidental falls occur.

Cold-laid binders have been tried but proved unsuccessful. The use of modified binders, with improved tenacity, that can prevent fatting up is being considered and some highway authorities are carrying out trials using polymer-modified emulsion binders. To date no performance data is available and there is an apparent need to provide advice on the use and specification of such treatments.

5. CONCRETE

The use of concrete in the construction of new footways was limited primarily to areas where extraordinary vehicular loading may occur or where overrun by heavy goods vehicle was a constant problem. Visually it was seen as being very unattractive. Where it had been specified, a minimum slab thickness of 150mm had been specified with mesh reinforcement placed at mid depth in the slab. The layer had been substantially increased where vehicle overrun was a significant problem and a 225mm slab thickness had been specified. C25P concrete was normally specified for light duty construction and C30P for heavy duty sites. Concrete was only used as a maintenance material to reinstate utility excavations already existing in concrete footways.

The acceptability of foamed concrete as a suitable material for the reinstatement of sub-base and basecourse in footways is recognised by the HAUC Specification. At the time of the survey, its use has almost been exclusively for reinstatements in carriageways and its potential as a construction or maintenance material for footways is possibly excluded on a cost basis. However, its ease of placing in confined areas and its self-compacting characteristics could commend it as a suitable footway material.

5.1 BLOCKS, FLAGS AND SETTS

The range of products conforming, in the most part, to British Standards within this group is extensive with a wide scope of different sizes, colours and surface textures. The type, size and shape of the product selected is clearly a subjective matter, but there is considerable advice available in construction standards. The traditional stone flag is now only utilised in prestigious locations. The trend is toward small element paving because of the need to deal with vehicle overrun. This is a particular problem in urban areas resulting in some highway authorities choosing reconstruct with flexible construction. Small element paving has been used to improve performance and appearance in some urban areas.

5.1.1 Dimensions

The standard block using clay or concrete pavers is a 200mm x 100mm rectangular unit but within this, the choice of texture, pattern and colour is considerable. Some highway authorities tried to impose restrictions on the type and colour used in order that stocks could be held for maintenance purposes. However, with manufacturers continually changing the type and colour of block manufactured, the future availability of some systems and alternative proposals from developers, may result in difficulties in maintaining these surfaces. Block thicknesses of 80mm were generally preferred where there was a risk of abuse by vehicular traffic and 50mm blocks where there was no possibility of vehicular traffic. The use of pencil arris (3mm) chamfered blocks was preferred for footway use because it provided a better walking surface than 6mm chamfered blocks. The choice of clay or concrete was a subjective matter with no advice given on the appropriateness of one or the other in any particular location.

The traditional 900 x 600mm size concrete paving flag was still extensively used in metropolitan areas but almost exclusively as a maintenance material. For new work, highway authorities generally selected either 450 x 450mm or 400 x 400mm to combat overrun problems. Larger flag sizes were considered vulnerable to damage by vehicular traffic. The choice of concrete paving block was often made in combination with block pavers for pedestrianised areas. Despite utilising the thicker slab thickness denoted in standards, some highway authorities reported breakages under severe loading. Concrete beds were specified where there is a risk of overrun. Some respondents to the questionnaire survey indicated concern over edge spalling of close jointed slabs and blocks with either no chamfers or small chamfers. This matter needs to be taken up and referred to the relevant British Standards Technical Committees. Revisions are now proposed to BS6717 (1986) and BS7263 (1990) requiring manufacturers to work to declared chamfer sizes.

5.1.2 Surface Finish

The range of surface finishes with flags was also wide and included the use of bar faced surfaces for difficult sites. The introduction of tactile paving flags to help the visually handicapped is one of the more important new forms of flag paving. However, not all concrete flag paving was recommended for use on the public highway. Some manufactured by the wet-cast method, which do not use air entrained concrete, were potentially likely to fail under trafficking and frost action when subjected to de-icing salts.

5.1.3 Potential Problems

Problems have been encountered with a laying coarse sands for block paving. The use of crushed rock fines as a laying course led to failure as the material degraded, unless it had been carefully selected. Degradation of some types under heavy load, in particular triassic sands, also led to block failure. Similarly sands containing excessive quantities of clay and silt fractions caused problems. Respondents to the questionnaire survey commented on such difficulties with bedding sands. Other problems, in relation to the performance of block paving, invariably involved poor laying and detailing rather than the type of block. However, the choice of inappropriate sub-base caused difficulties and the use of only granular Type 1 sub-base or bound material was recommended.

A common problem mentioned in the questionnaire survey was the loss of jointing sand in block paving or small element paving which led to subsequent failure. The need to re-sand at frequent intervals after laying was noted, particularly in view of the use of small suction sweepers for street cleaning which have the ability to suck sand out of joints. Various materials were utilised to stabilise the sand. Several proprietary additives and sealants were used to stabilise joints but most highway authorities were not convinced that these systems were successful, although one authority reported the successful but expensive use of an epoxy mortar. Trials in Northern Ireland suggested that small element paving performed more satisfactorily under vehicle overrun conditions when constructed with a 3mm sand filled joint compared to the normally 6mm sand/cement mortar joint.

The use of setts and stone paving was now restricted to unique and special location sites and not regarded as a common footway surfacing.

6. SUB-BASE MATERIAL

Granular Type 1 sub-base, as specified in the Department of Transport Specification for Highways Work (SHW) (1991) Clause 803, was almost exclusively used other than where recycled materials were utilised. Some specifications allow the alternative use of Type 2 material but this option is rarely taken up. Some respondents to the questionnaire considered that a smaller nominal size material would be beneficial when attempting to use it in relatively thin layers and when segregation could make compaction difficult.

7. RECYCLED MATERIALS

The major emphasis on recycling at the present time was associated with the reuse of coated materials. In a basic form, footway materials could be planed or crushed to a form where they could be incorporated in a lower layer of construction. If recycled material was to become acceptable then it must have a similar performance and be as cost effective as new material.

7.1 THE PRESENT POSITION

Continued development of in-situ recycling with bitumen, bitumen emulsion or modified bitumen emulsion binders to form a base material is under investigation. The base layer is overlaid with a wearing course. The cost effectiveness of such treatments seemed to vary around the UK. A number of highway authorities carried out recycling projects, for the most part in a non-comparative trial basis. Others had rejected this approach in view of a minimal cost saving over reconstruction. There was virtually no performance data or reported experience on the recycling of footways.

Recycling can be categorised into four broad areas considering both in-situ and in-plant techniques and hot and cold systems. In the context of footways, recycling can reuse material taken from one site on another. Hot in-situ repave, as far as footways are concerned, typifies the use of mobile mixers such as the Bomag AR6 recycler which reuses cold-planed material. This technique proved relatively unsuccessful since it was very dependant on the quality of planed material and operator skill. This concept has now been withdrawn from general use.

7.2 COLD IN-SITU RECYCLING

Under the category of cold in-situ recycling an alternative, where a flexible footway had suffered considerable degradation, was to break up or scarify all the existing in-situ bituminous materials and any granular sub-base materials, reshape and remove any excess and apply a single surfacing layer, normally a 20mm thickness of wearing course macadam. This retread technique has been carried out by numerous highway authorities either as a proprietary operation or based on in-house methods. One authority in the North of England who adopted this policy on its flexible footways, outside its City Centre area, commented that the technique could provide a footway with a life of twenty years if the surface was not subject to overrun. It was added that overrun would cause severe problems to this method of construction. In the view of some survey respondents, the inability to adequately control shape and profile was a limitation of this retread technique.

Another highway authority was experimenting with recycling using cement as a binder. The initial experience was encouraging but the technique proved to be an expensive operation.

7.3 RECYCLING OF PLANINGS

The recycling of planings with a view to blending with new material in a hot plant mix has been the subject of trials within the carriageway, but no use of such material in the footway is documented. The reuse of crushed and screened planed material using proprietary rejuvenating binders such as Cyclade has found favour in the manufacture of a footway basecourse. Similarly the injection of foamed bitumen into planings to produce a sub-base/roadbase using a purpose built plant has been developed. The advantages of these materials is that the material can be manufactured in a mobile plant, on site if necessary, and stored until needed. The performance of these materials in footway usage is unknown at present.

Beyond these considerations for footway repair, a further technique is particularly appropriate for footway construction where small quantities of macadam are required. The use of a site mini-mobile batching plant capable of mixing 20mm basecourse material and 6mm wearing course from pre-blended aggregates and solid bitumen blocks eliminates the need to supply small quantities of material and minimises the possibility of material being laid cold. As yet no data is available on the performance or cost effectiveness of material manufactured by this technique.

The most common form of recycling carried out by highway authorities was the use of bituminous planings as a fill/granular subbase layer. Most highway authorities reported that well-graded planings particularly those from macadams performed satisfactorily, although asphalt wearing course planings tended to be lively under compaction because of their higher binder contents. The controlled use of such planings, because of their cohesive qualities, could permit the application of a single surfacing layer; a thicker than normal wearing course. However, because the planings are still a visco-elastic material, there is a possibility of consolidation of thicker layers. Some highway authorities expressed concern about the effect of double handling of planings and the cost of such an operation. The stockpiling of planings can cause management difficulties and the introduction of the Environmental Protection Act has caused highway authorities to abandon this approach. TRL has carried out a trial using bituminous material as sub-base and the work is continuing.

8. COMPACTION OF BITUMINOUS AND GRANULAR MATERIALS

A significant problem identified from the questionnaire survey was the compactability of certain aggregates. With wearing surfaces being laid in relatively thin layers the ability to compact aggregates to achieve a low air voids content is crucial for long-term performance and durability. Dense macadam materials are relatively difficult to compact because of their continuous grading and relatively low binder content. The influence of aggregate shape on compactability is important, although Standards provide no advice in this respect, and a method specification is adopted for compaction. It is recognised that with a method specification, similar mixtures receive a similar compactive effort, and although they contain different aggregates, it can result in different performance with one material more prone to fretting and susceptible to weathering and frost action. Subject to local experience of this and some local selection, the need to adopt end performance testing was seen to be the main objective to resolve this problem.

The compaction of material that had been allowed to cool was also seen as a problem because of the small-scale nature of maintenance works. In general, small quantities of bituminous material can, because of thin layers, give relatively large coverage and as a consequence material is allowed to cool before being placed and compacted. The use of hot-box storage is a potential solution, but before this occurs, highway authorities need to be convinced of the importance of monitoring and supervising footway construction to specification standards.

Because of the confined areas of work, the compaction of bituminous material is normally by the use of pedestrian rollers and a method specification is universally adopted. Manual compaction is often applied around street furniture and other restricted areas. A further restriction on compaction is the presence of utilities' apparatus. In order to achieve the required level of serviceability, a high level of compaction is required and the restrictions imposed in footway compaction can limit performance. With this consideration it is important that the method specification is followed and that adequately trained and supervised resources are available to ensure the requirements are achieved.

Although materials like granular sub-base require a high level of compactive effort, there is considerable concern about the limitations of compaction plant available for use on footway construction, especially with the level of supervision and the method specification in the Department of Transport Specification for Highway Works (SHW) (1991) for the compaction of granular and bituminous in footways. Highway authorities appreciated this problem and reacted with over design to compensate for less than adequate compaction. The HAUC Specification gives specific advice on the compaction of granular layers providing a more rigorous method specification than SHW and with particular advice in respect of restricted access. It is considered that the HAUC method of specification should be adopted for footway materials.

9. PERFORMANCE OF SURFACING MATERIALS

The performance of materials for both footway surfacing and base materials is being compromised by inadequate quality. Firstly, there is a failure to adequately specify requirements, and secondly, there is a failure to ensure that those specification requirements are followed. Failure to carry out or to even consider compliance testing of footway materials is totally unacceptable. A major initiative is required to address both of these points to improve specification compliance and to improve performance of materials. The use of poor materials, inadequately specified materials, inadequate construction, poor workmanship and out of specification materials jeopardises the performance of footways and, as such, sufficient resources need to be given to ensure that the position is significantly improved.

9.1 RESEARCH

It is quite apparent that there has been very limited research into the performance of footway surfacings. This is particularly relevant when attempting to quantify performance of proprietary mixes, acceptance of which are made on the basis of trade name and any previously subjectively acceptable performance. Some work has been undertaken in respect of cold-laid materials, proprietary mixes, recycled materials and remix processes for highway pavements, the findings of which would be potentially applicable to footways.

9.1.1 Cold Lay Materials

Research on cold lay materials suggests that such mixes could have considerably less structural stiffness than hot laid mixes. The development of a laboratory test to measure the compactability of cold lay materials is of particular significance to the compaction of footway material.

9.1.2 Off-site Recycling

Cornelius and Edwards (1991) reported on the recycling of bituminous materials off-site and stated that the performance of asphalt wearing courses and macadam bases was comparable to new material, whilst rolled asphalt base materials containing up to 60 per cent recycled material performed satisfactorily. Potential savings are possible and, although the work was directed at highway materials, there is clearly further potential for use of such material within the footway and as such, the results of current research on highways would be applicable to footway construction and maintenance.

9.1.3 Resistance to Polishing

The resistance of a footway surfacing to polishing is a matter for consideration. Specifications rarely dictate measures to address this and yet it is clearly of concern to highway authorities who carry out surface treatments to provide a textured surface.

9.1.4 Performance Assessment

It is apparent that the research on performance assessment that has been conducted has been done so in an ad-hoc way with little detailed reporting. It is clearly necessary to evaluate the cost effectiveness of surface type treatments against reconstruction. There is a significant need to gather performance data in respect of footway surfacings and to identify specific research needs in order to establish preferred maintenance treatments and designs. Considerable opportunity is afforded in this respect because highway authorities are constantly conducting trials of new materials. Highway authorities need to be encouraged to undertake these trials in a controlled way, evaluating the performance of trial sections against control sections and then report findings in a simple and effective manner. The evidence of surveys showed that there was potential for co-ordinating trials within existing resources. One highway authority commented specifically on this point with the need to pool information on performance. The use of the RAPID database is eminently suitable for this purpose but at present inclusion of reports on footway maintenance is minimal.

It is evident that research is required into the use of modified bituminous materials, both hot and cold laid materials, to evaluate their usefulness and cost effectiveness. Recycling including the use of planings needs to be considered so that the performance of such materials can be adequately assessed.

10. CONCLUSIONS

The selection and development of materials with adequate storage life and appropriate surface and performance characteristics are predominant issues.

Traditional large paving flags are considered vulnerable to vehicle overrun and smaller elemental paving is preferred where overrun is likely.

The performance of materials is compromised by inadequate quality, either by a failure to adequately specify requirements or ensure that specifications are adhered to.

There is considerable scope for the use of recycled materials but their use is limited by the lack of research into the performance of footway surfacings or the effectiveness of recycling techniques. The need to gather performance data and identify specific research needs is seen as a vital task.

CHAPTER 5. MONITORING EQUIPMENT AND TECHNIQUES

CONTENTS

CHAPTER 5. MONITORING EQUIPMENT AND TECHNIQUES

SUMMARY

It is conservatively estimated that £300 million is spent annually on footway maintenance nationally. This figure is likely to increase because of the higher expectations of the public generally, increased facilities for the mobility handicapped, increasing personal injury litigation and new legislation. The HAUC Specification requires the accurate measurement of reinstatement profile against clearly defined intervention criteria. The requirements of the Department of Transport Routine and Winter Maintenance Code (1992) and the Local Authority Associations' Code of Good Practice (1989) have also encouraged more quantitative measurement of footway condition.

At present, most maintenance engineers rely on subjective visual assessment systems such as Maintenance Assessment, Rating and Costings for Highways (MARCH) and Computerised Highway Assessment of Ratings and Treatments (CHART) to rank prospective repair schemes in an order of priority.

In 1992, the Footway Maintenance Working Group, set up by the Working Party on Highway Research, commissioned research to examine and evaluate methods of identifying and quantifying a range of defects. A literature review found that, of the 25 existing profile measurement devices examined, two had the most potential. These two, the British Gas Road Profile meter and the WDM Footpath Profiler were evaluated against a provisional Footway Profilometer specification and Highway Inspectors' assessments in a series of tests on in-service footways and artificial surfaces. Pedestrian assessments of serviceability were shown to be correlated with a function of footway profile, and profilometer output could be used to obtain maintenance intervention levels. Results were used to derive an end product/performance specification for a range of Footway Profilometers.

1. INTRODUCTION

At present, the majority of Highway Authorities rely upon subjective, visual assessment systems to rate maintenance treatments in an order of priority. Available funds can then be allocated to those areas where the need is most urgent.

Maintenance Assessment, Rating and Costing for Highways (MARCH) is currently used by 48 highway Authorities, 30 of which are Metropolitan District Councils. All Department of Transport agents use the structural maintenance management system, Computerised Highway Assessment of Ratings and Treatments (CHART), to assist in formulating programmes for the structural maintenance of carriageways, footways and kerbs.

The desire to provide walking surfaces, and the increase in litigation following pedestrian injury accidents, have highlighted the need to accurately monitor the performance of footways. Recently introduced legislation, such as the HAUC Specification requires the accurate measurement of reinstatement profile against clearly defined intervention criteria.

Mainly subjective systems, such as CHART and MARCH are not ideally suited to the requirements generated by the increased emphasis of the need for qualitative measurements of footway surfaces. Experience suggests that the outputs of the CHART and MARCH systems can be very variable, depending upon a large number of factors such as individual authority policies and the standard of training given to the inspector.

2. OBJECTIVES

The primary objective of footway maintenance is to keep footways safe and comfortable for pedestrians, with some regard for the appearance, while ensuring that expenditure is both cost-effective and justified in terms of the present and future use.

Maintenance needs can arise due to general deterioration, localised damage or specific deterioration. A method of condition assessment should be defined and standards and warning levels set. These should then be integrated into a maintenance management system. The allocation of funds can then be provided on the basis of need. Information about other factors such as treatment options, cost effectiveness of maintenance operations, trends and budgetary considerations are also required.

3. INVENTORY AND CONDITION ASSESSMENT SYSTEMS

In order to maintain the footway an inventory of assets must be made e.g. location, length, width, construction, condition and pedestrian flows etc. Details of street furniture in the footway, pedestrian accident records and complaints are also required.

A Directory of Maintenance Management Systems has been published by the County Surveyors' Society (November 1990). It contains a comprehensive list of the following systems:

1. General Information Management Systems
2. Dedicated Routine Maintenance Management Systems
3. Highway Condition and Maintenance Assessment Systems
4. Other Maintenance Management Systems
5. Winter Maintenance Systems.

Inventory items, including footways, are an integral part of most of these systems.

At present, among the main condition assessment systems used for inventory collection on Department Roads and Local Authority roads are:

1. Routine Maintenance Management System (RMMS - DOT/TRRL)
2. The Code of Good Practice (LAA's etc.)
3. Maintenance Assessment Rating and Costing for Highways (MARCH)
4. Computerised Highway Assessment of Ratings and Treatments (CHART/TRRL).

Other inventory items relating to bridges e.g. pedestrian bridges, road bridges, railway bridges and viaducts are listed in the bridge directory.

4. HIGHWAY CONDITION SURVEYS

There are various systems available to assess and prioritise highway and footway maintenance. The most widely used are MARCH and CHART. They are not specifically tailored for the assessment of footways. However, they do relate footway condition defects to priority listings for remedial treatment. The defects include cracking, crazing, fretting, deformation, dangerous defects, local deterioration, general deterioration, rocking/cracked slabs, settlement, kerb upstand and kerb deterioration.

The main routine and condition assessment systems are described in detail in Chapter 1, Methods of Management.

4.1 CHART - COMPUTERISED HIGHWAY ASSESSMENT OF RATINGS AND TREATMENTS

At present, all DOT agents use this system. It offers a comprehensive set of facilities and CHART inspection data are input into it. Inspections are commonly carried out on a one to three year cycle. The CHART program allows lengths of footway that are not within standards to be identified and located and then recommends what remedial maintenance is required to restore the condition to bring it to within standards. The various treatments are listed in order of priority. The engineer can then decide on implementation based on the available funds.

4.2 MARCH - MAINTENANCE ASSESSMENT, RATING AND COSTING FOR HIGHWAYS

MARCH is currently used by 48 Highway Authorities, 30 of which are Metropolitan District Councils. Inspections are commonly carried out on a one to three year cycle. The system uses intervention levels related to the quantity of the defect. The defects are aggregated for each section length on the footway and when the deterioration levels exceed user defined intervention levels a treatment is triggered. The treatments are costed and each length is assigned a priority. The system also has network routeing capabilities.

4.3 UKPMS - UK PAVEMENT MANAGEMENT SYSTEM

Item inventory, including footways, will comprise part of the UK Pavement Management System (UKPMS) currently being developed by the Department of Transport in partnership with Highway Authorities. There will be a minimum of 15 inventory items provided and the system allows for the recording of the details of these items. Collection of inventory items using existing systems will still be possible within the framework of UKPMS.

At present UKPMS has completed development and trials. It is expected that other systems will be modified to become compliant with UKPMS now that the Logical Design has been released.

The development of UKPMS will facilitate the management of treatment histories for all roads and the application of Whole Life Costing.

The noteworthy features which will make UKPMS different from existing systems are outlined below:

(a) It will cover flexible and rigid pavements, footways and cycletracks.

(b) A coarse assessment and a detailed assessment with different standards and techniques are proposed for DOT roads and local roads.

(c) A flexible locational referencing approach is proposed which will accommodate existing systems.

(d) Provision for priority ranking on the basis of short term projections of pavement performance instead of current condition.

(e) An economic testing facility to allow the most cost effective treatment for a defective length of pavement to be identified, thus facilitating priority ranking of treatment schemes on the return from investment over a short period.

(f) A Pavement Management System data interchange format as a standard means of inputting data from survey machines.

There will be survey procedures for four different types of visual inspection:

(a) Annual engineering inspection (AEI)

(b) Coarse visual inspection (CVI)

(c) Aggregated visual inspection (AVI)

(d) Detailed visual inspection (DVI)

AEI is a cursory inspection from a moving vehicle and enables inspectors to rate defects directly on a scale 1-10, with separate rating values for carriageway, edge and footway. CVI scores defects in terms of severity and length over defined defect lengths within a section. AVI is a MARCH-like inspection based on the recording of aggregated, or percentage, values over whole sections. DVI is a CHART-like inspection which records summaries of defects over relatively short subsections.

All inspections can be used on footways. More defects types have been considered than in RMMS, CHART and MARCH surveys.

5. NRMCS - NATIONAL ROAD MAINTENANCE CONDITION SURVEY

NRMCS is sponsored jointly by the Local Authority Associations and the Department of Transport and the Welsh Office. The survey is designed to provide statistically significant information about trends in carriageway and footway condition. It provides two types of information:

(i) A defects list for seven classes of carriageway and footway. From this a defects index is built up by weighting together the results for individual defects according to the relative cost of repair.

(ii) A residual life assessment for trunk and principal carriageways and footways.

6. FOOTWAY STANDARDS AND COMPLAINTS

Footway standards vary from area to area. Public acceptability of these standards is of equal importance to the specified standards in determining complaints and claims. The rate of complaints per kilometre is generally higher on flagged footways and is most likely related to the predominant use of this type of material in heavily pedestrianised areas.

Some sources suggest that an estimated three million people may suffer some sort of accident on a footway each year and, according to the findings of the Association of Municipal Engineers Survey (1993), liability claims can cost Highway Authorities up to £4000 per thousand residents each year. Accurate monitoring of footway performance and serviceability could optimise maintenance costs and reduce litigation following personal injury accidents.

The first step towards a systematic assessment of footway condition in all areas would therefore be the development of a common scale of condition assessment and maintenance intervention.

7. FOOTWAY PROFILOMETER

The Footway Maintenance Working Group, formed by the Working Party on Highway Research, set up a Profiler Subgroup in 1992 to examine and evaluate methods of assessing and quantifying footway condition against defined intervention criteria.

A literature review of existing and proposed profile measuring equipment by Spong (1994) found that, of the 25 existing devices examined, two had the most potential for satisfying the requirements of the provisional specification. These two were the British Gas Road Profile Meter and the WDM Footpath Profiler.

A series of tests on in-service footways and artificial surfaces, reported by Spong and Cooper (1994) was designed to test the performance and suitability of the two machines against a provisional Footway Profilometer Specification and Highway Inspectors' assessments. Objective measurements of footway profile were compared with the subjective impressions of footway serviceability using a sample of the walking public.

Results showed that both machines could accurately measure typical footway defects with repeatable results, but in their present form they were not completely suited to routine surveys of footway condition.

The output from both machines agreed reasonably well with the judgement of Inspectors using the MARCH and CHART systems demonstrating that they could be used to place the test sites in the same order of deterioration as the inspector.

It was concluded that, because of their limitations, neither machine would be an efficient replacement for an inspector. However, a profilometer could be used in conjunction with an inspector to provide absolute measurement of sites identified as being defective or on heavy duty and high amenity footways where defects need to be detected and repaired rapidly.

The results also indicated that longitudinal and transverse profile measurements could be used to derive indices of irregularity which are closely related to pedestrian subjective impressions of footway serviceability. These indices could be used to formulate intervention levels incorporated into a monitoring system which, when based on the use of the machines, would be able to rate footways in order of their maintenance needs.

Objective measurements produced could be used over time to identify trends in footway deterioration. This would enable predictions of remaining life to be incorporated into a Whole Life Cost model and maintenance expenditure to be optimised.

Although more work is needed to establish reliable maintenance intervention levels closely related to the level of usage and overall cost-benefits, the research results have been used to obtain a generic end product/performance Footway Profilometer Specification, described by Spong and Cooper (1994). It is hoped that this work will aid the development of a range of footway assessment machines for use on a wide range of surfaces.

8. CONCLUSIONS

Recently introduced legislation requires the accurate measurement of reinstatement profile against clearly defined intervention criteria.

At present, most maintenance engineers rely on subjective visual assessment systems to rank prospective maintenance schemes in an order of priority.

Objective measurements of footway profile using a footway profilometer have been related to Highway Inspectors' assessments and pedestrians' subjective impressions of footway serviceability. Results of this research have been used to devise a generic end product/performance specification for a Footway Profilometer.

CHAPTER 6. INTERVENTION LEVELS

CONTENTS

CHAPTER 6. INTERVENTION LEVELS

SUMMARY

Of the Highway Authorities surveyed, 70 per cent indicated that they had set standards for maintenance. The LAA Code of Good Practice (1989) is used by 38 per cent of those who have set standards and the remaining 62 per cent did not clarify the basis on which their standards were set. The remaining 30 per cent of Authorities responded that they did not have defined maintenance standards.

Since the operation of any major inspection based system requires the establishment of standards against which it can work, the setting of maintenance standards is very important. There appears to be a need for clear understanding of the separate terms Warning Level and Intervention Level.

The origins of the published warning levels are not clear although there is evidence that they relate to what has generally been understood to be current practice. Budget constraint was noted as a factor inhibiting the definition of maintenance standards for footways where maintenance is usually finance led rather than needs led.

A clear definition of the standard of service is required against which a rational funding argument can be developed. The efficient use of limited maintenance funding requires an effective management of footways and clearly defined, easily understood standards. These standards must be defined in terms of user requirements.

There is a need for research work in establishing warning and intervention levels which can be interfaced with optimal Whole Life Cost maintenance procedures and user requirements.

The development of a footway profilometer would lead to the provision of objective data which when related to realistic, well defined, footway condition indices and intervention levels could be used in conjunction with Whole Life Cost models.

1. INTRODUCTION

Whilst the survey undertaken indicated that 70 per cent of Highway Authorities had set standards for maintenance, only 38 per cent were related to the LAA Code of Good Practice (1989). The definition of clearly understood standards is fundamental to an effective system of maintenance management.

In a rational maintenance system, standards of service are defined and the current condition of the footway is established by inspection. The variance between this and the defined standard represents the maintenance need. When a new footway is constructed it is assumed that its condition is at the maximum (best) at this time. Its serviceability deteriorates with time and this relationship is exponential as shown in Figure 1. If this curve can be defined for a wide

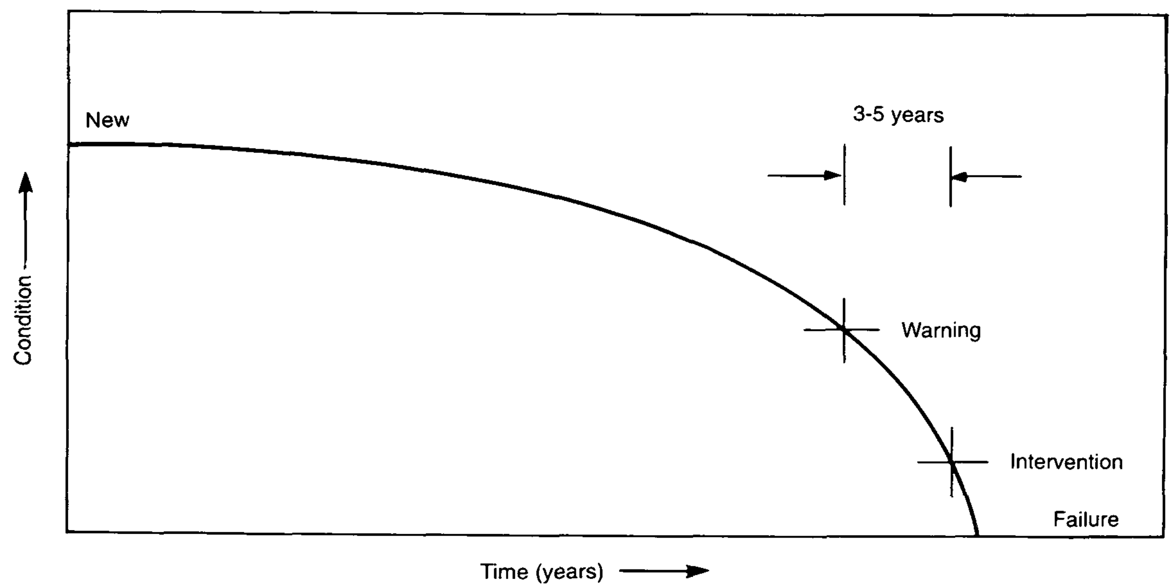


Fig. 1 Deterioration/Time relationship

range of different types of construction, then it is possible to determine how long it will take to reach a predetermined state from its existing condition thus enhancing maintenance planning.

Two levels of condition are considered:

- **Warning level** - Represents a point on the deterioration curve when consideration must be given to some form of maintenance in a future programme which could be several years away. This state of deterioration may well be related to the onset of user dissatisfaction.

- **Intervention level** - Represents the point on the deterioration curve where the level of serviceability becomes unacceptable and remedial works are required. This standard may well be related to the incidence of a predetermined level of personal injury accidents. The choice of maintenance action will depend upon the nature of the defects and the cost-effectiveness of the treatment.

Weller (1980) commented that "The Marshall Committee envisaged that their recommended standards were targets to be achieved. Experience in use has shown that the standards should rather be regarded as warning levels that inform the maintenance engineer about lengths of road that have reached certain defined levels of deterioration and that should be given closer examination to decide the urgency and type of treatment required." A similar situation has arisen in the case of footways where the LAA Code of Good Practice sets out guidance on warning levels and these have tended to be regarded as the levels of deterioration at which work is programmed. In practice, however, the threshold levels related to a priority rating programme are determined by the availability of funds rather than a defined level of deterioration.

2. WARNING LEVELS

Warning levels require a detailed knowledge of the time-deterioration relationship of the structure and should be set to give a three to five year forward indication that work is necessary. The manner in which they are expressed should be identical to that of intervention levels.

3. INTERVENTION LEVELS

Intervention levels are the levels of deterioration at which the walking surface becomes unserviceable. They are also a major determinant in the acceptability as perceived by the pedestrian user. An attempt to define some of these requirements was reported by Leake et al in the IHT Journal (July 1991). Extracts from this article are given in Appendix 6.A.

In general, whereas the LAA Code of Good Practice deals primarily with bituminous surfaces, as shown in Appendix 6.B, Leake et al dealt mainly with the modular surfaces which predominate in urban areas. The results of the research, carried out on surfaces in Sheffield, indicated that the walking public were considerably more discriminating and demanding than had previously been thought.

In addition to the normal trips and gaps it was established that relative unevenness was a primary concern to the pedestrian. In the event of a trip, gap or normal surface deterioration these tend to be visible and in many cases can be allowed for by the pedestrian. Unevenness, on the other hand is not generally visible but could be a major cause of accidents.

The LAA Code of Good Practice (1989) envisages a range of modes of deterioration as follows:

Projections (including ironwork)

Dangerous rocking flags

Cracks or gaps between flags

Isolated potholes

Depressions or bumps

Slippery surfaces

and comments that the speed of response will be related to the intensity of use and the degree of danger. The degree of danger relates to the probability of there being a pedestrian accident, with or without personal injury. Due to the considerable range of ambulatory abilities of pedestrians there is serious difficulty in assessing this probability. It may be argued, for example, that any rocking flag is dangerous as a matter of course to all pedestrians.

Contemporary thinking related to trips has been confined almost solely to the maximum vertical displacement on the assumption that their incidence will be isolated. There is a reasonable probability that any personal injury claim will be successful where the accident occurred at a trip exceeding 20mm.

The Characteristic Trip Incidence, described in the Highway Maintenance Handbook (1990) and shown in Figure 2, indicates that the distribution of trip magnitude may be more important than individual maximum values. It is believed that there is a good correlation between the serviceability and the characteristic trip incidence. Of particular significance is the relative shape of the distribution expressed in terms of standard deviation. The evaluation of surfaces in this manner could be carried out using a Footway Profilometer.

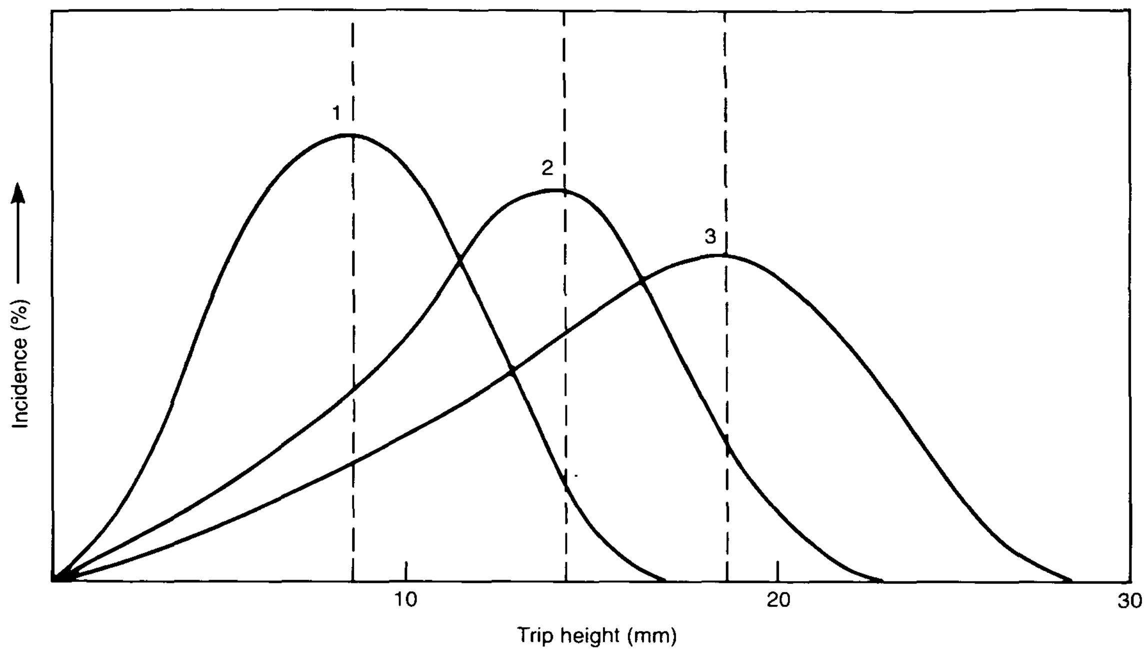


Fig. 2 Characteristic Trip Incidence

The figure shows three different distributions, with different values of mean and standard deviation. A normal distribution, such as 1 in the Figure has 99.73 per cent of all readings within $\pm$ three standard deviations, and there is a low incidence of trips greater than about 15mm. The distributions 2 and 3 are slightly skewed showing a wider range of trip heights which have higher mean values and a larger number of trips of amplitude greater than 10mm. Distribution 3 is the worst case with a high proportion of trips of amplitude greater than 20mm. During its life a footway surface will progress through the stages shown by distributions 1, 2 and 3. It should be possible to use plots of characteristic trip incidence to determine when maintenance action is needed. To achieve this objective, subjective impressions of serviceability and the probability of injury accidents will need to be correlated with causes of characteristic trip incidence.

There is an almost total absence of data relating to slipperiness or skid resistance. Whilst slipperiness is not generally regarded as a problem on footways there is some evidence of accidents being related to low values. Progressively there has been a move towards smoother and harder surfaces particularly in shopping precincts. The danger for many of these surfaces, when wet, may become apparent if emergency evacuation is necessary. There is evidence of an increasing number of personal injury accidents on these smoother surfaces although statistics are obviously closely guarded.

It might be appropriate to standardise on the TRRL pendulum tester to establish information on skid resistance and for a series of threshold values to be determined. It may also be relevant to establish a minimum texture depth and investigate the relationship between skid resistance and texture depth. However, the measurement of skid resistance and texture depth is a lengthy and, in the case of skid resistance, a tedious operation. It would possibly be better to investigate the avoidance of personal injury accidents that are related to low levels of friction to determine the need for a higher coefficient of friction on footways and estimate any cost benefits that might be obtained. Also it should be possible to choose surfacing materials with a proven history of acceptable skid-resistance performance and for which routine on-site measurement of skid resistance or texture would be unnecessary. There might however, be a case for routine monitoring of heavily trafficked areas. More research is needed to establish priorities and improved monitoring methods.

The influence of the higher expectation of the walking public is likely to increase as highway authority funds become scarcer and concepts like the Citizen's Charter take effect. Similarly, the move towards published maintenance plans and performance reviews will all help to focus on the standards which are and are not being achieved.

4. CONCLUSIONS

The realistic determination of warning and intervention levels requires a combination of consumer survey and economic evaluation.

Relative unevenness is of primary concern to pedestrians. Although generally visible to the pedestrian, it could be a major cause of accidents. It would be prudent to encourage the development of a Footway Profilometer to evaluate the relative shape of distributions of unevenness in terms of standard deviation. Pedestrian subjective views of footway surfaces can then be correlated with objective measurement to provide a range of footway condition indices.

This is best accomplished as part of a structured Whole Life Cost evaluation where the economic consequences of different standards of service are considered with the economic cost to society of the implementation of those standards.

The development of this information will also allow for the determination of the deterioration curves which are necessary if meaningful warning levels are to be defined. This will enable a more rational long-term maintenance strategy to be developed.

Comparison of Leake's work with the LAA Code of Good Practice indicates that the expectation of the pedestrian is considerably more demanding than has previously been considered. It will be necessary for Highway Maintenance Management to respond to this challenge.

APPENDIX 6.A

Extract from Leake et al - Journal of the Institution of Highways and Transportation - July 1991
Recommended threshold standards, by footway type (based on a pedestrian subjective response value of three)

Surface	Sex	Undulation (Standard Error, mm)	Raised edges >5mm (%)	Friction (Skid Pendulum value)	Broken pavers (%)	Gaps >10mm (%)
Block paving	M/F	<10-11*	x	>65	<10(R)	x
Conventional flags	M	<11	<12.0	>65	<10	<4.0
	F	<11	<12.0	>65	<10	<1.0
Small element flags	M	<10	<9.0	>65	<10(R)	x
	F	<10	<9.0	>65	<10(R)	x
Black top	M/F	<14-15*	N/A	>65	N/A	N/A

Note: All measurements relate to a test area 10m x 2m

Key:
- * tentative recommendation;
- x no standard obtained;
- N/A not applicable;
- M/F Male/Female;
- (R) Recommendation based on conventional flag results

APPENDIX 6.B

Extract from the LAA Code of Good Practice (1989) section 1(b)
Footways and Cycleways pps 38,39

Footway and Cycleway Warning Levels

Group to which applicable	Limitation or Severity	% of area	Treatment
I Main shopping areas		20	Restore surface
IIa Busy urban/shopping (flexible)	Coarse cracking of the surface. Coarse crazing. Depressions more than 25mm deep. Trips greater than 13mm but less than 20mm.	30	Restore surface
IIb Busy urban/shopping (rigid)	Trips more than 13mm but less than 20mm. Cracks or gaps more than 20mm wide and more than 6mm deep. Rocking flags which are not dangerous. Depressions more than 25mm deep.	30	Restore surface
III Less used urban and busy rural (flexible)	As for busy urban (flexible)	40	Restore surface
III Less used urban and busy rural (rigid)	As for busy urban (rigid)	40	Restore surface
IV Little used rural	When potentially dangerous		Patch or restore surface

Note: Choice of surface treatment will depend on the favourite mode, type of construction and importance of the footway or cycleway. Generally less used footways would only require surface treatment and heavily used ones reconstruction of the surface. Although not specified separately, cycleways should be treated to urban standards in normal circumstances.

CHAPTER 7. WHOLE LIFE COSTING

CONTENTS

CHAPTER 7. WHOLE LIFE COSTING

SUMMARY

In order to compete for scarcer funds, it will be necessary to use some form of investment analysis or proxy.

The fundamental steps in securing funds for the management of infrastructure are:

(a) to rationally justify what funds are needed;

(b) to prioritise how the funds are spent; and

(c) to evaluate the effectiveness with which the funds were spent.

In these circumstances it is necessary to consider the normally separate stages of design, construction and maintenance together. This can most effectively be done using a Whole Life Cost analysis which acts as a discipline to a detailed evaluation of the discrete parts.

Investment decisions are often subjective if Whole Life Costs are not taken into account. They are dependent on the application of standards which often are themselves based on historical precedent rather than objective analysis.

There is a trade-off between construction and maintenance costs. Clearly, the higher the design standard, the stronger the structure and the more resistant it will be towards deterioration and abuse, but the initial cost will be higher. A principal use of Whole Life Costing is to investigate standards and policies that optimise the balance of resources between these two aspects of investment.

The utilisation of design and maintenance standards arrived at as the result of a Whole Life Cost investigation will provide an initial standard. Revision or confirmation will be required as more and better performance data become available.

1. INTRODUCTION

It is reasonable to draw an analogy with the development of Maintenance Management Systems over the last 15 years where it has taken a considerable time to appreciate that a common locational referencing of maintenance sections is fundamental to the structure of any successful system. The concept of Whole life Costing is the common factor which allows the constituent parts to interrelate in an investment analysis.

As funds become scarcer it is necessary to compete for them with increased vigour and wherever possible it is appropriate to use some form of investment analysis or proxy.

There are three fundamental steps in the allocation of funds for the management of infrastructure:

(a) to rationally justify what funds are needed;

(b) to prioritise how the funds are spent; and

(c) to evaluate the effectiveness with which the funds were spent.

In these circumstances it is necessary to consider the normally separate stages of design, construction and maintenance together - as mechanical/production engineering currently describes it concurrent engineering. This can most effectively be done using a Whole Life Cost analysis which acts as a discipline to a detailed evaluation of the discrete parts.

If whole life costs are not taken into account, investment decisions can become subjective and dependent on the application of standards which are often themselves based on historical precedent rather than objective analysis. The rational formulation of standards should also depend on whole life cost considerations.

There is often a trade-off between construction and maintenance costs. Clearly, the higher the design standard, the stronger the structure and the more resistant it will be towards deterioration and abuse, although the initial cost will be greater. A principal use of Whole Life Costing is to investigate standards and policies that optimise the balance of resources between these two aspects of investment.

2. RESULTS OF QUESTIONNAIRE SURVEY OF HIGHWAY AUTHORITIES

In the survey the authorities were asked:

What they understood by the Whole Life concept

It is apparent that there is a lack of awareness of the Whole Life concept since 57 per cent either did not answer the question, said they didn't use it or it was not applicable.

As the Whole Life concept is considered to be fundamental to the development of a rational funding argument, especially when monitoring of the management of scarce resources is concerned, this lack of awareness gives cause for concern.

To specify the design life for various constructions

The average life of various constructions was given as:

Bituminous	21 years
PCC flags	40 years
Block paviors	60 years
Natural stone	100 years

The expected expenditure split between construction and maintenance

Four authorities answered this question with the result:

Capital	60.0 per cent
Maintenance	40.0 per cent

How user costs might be evaluated

11 authorities answered, all suggesting that the use of accident claims might be the best method of evaluating user costs.

3. BACKGROUND

The technique of Whole Life Costing was recorded in 1870 in the City of London. It emerged again in the late 1960s and has been part of the Cost Optimisation and Benefit Analysis (COBA) for new road evaluations since the early 1970s. Receiving greater consideration from the mid 1980s onward it was introduced into the pavement Design Standard in 1987 and has now become a firm part of the investment appraisal associated with new highways.

Garrett (August 1985), set out a helpful statement of the use and potential of Whole Life Costing for Roads. This was a concerted attempt to persuade people to think in total investment terms and to move away from cheapest first cost concept.

There was a shortage of published illustrative work until 1986 when Abell et al (1986) reported on work at TRL on the Estimation of Life Cycle Costs for Pavements at the International Conference on Bearing Capacities, Plymouth 1986.

In the Highway Maintenance Handbook (1990) Pearson proposed a crude model which attempted to describe a way forward for footways. It was acknowledged that there were two particular weaknesses, firstly as with all previous work there is limited data credibility. Secondly, the comparison was annualised and not discounted.

Further work by CIRIA (1991) suggested that a limited time horizon of 3-5 years was necessary to obtain maximum benefit. The report did, however recommend that contractors be encouraged to offer a life-cycle price but suggested its use was only recommended where the various constituent parameters are well known.

4. WHOLE LIFE COST MODEL RELATED TO FOOTWAYS

Despite the difficulties associated with the clarification of some of the data the fundamental concept of total cost and benefits is conceptually straightforward.

Whilst the refinement of a discounted cash flow evaluation is relevant and necessary as an integral part of investment appraisal, the stability of the economic situation conspires against it.

Regardless of all the problems of data reliability it is, however, desirable to go forward for the reasons set out in the introduction.

One fundamental purpose of a Whole Life cost investigation is to consider the relevance and relative economics of different constructions.

The premise behind Pearson's model for footways was:

- Establish whole life costs for bituminous construction and use as the limiting case.
- Establish whole life costs for modular construction using a variable maintenance activity parameter.
- Evaluate maintenance activity levels where whole life costs for bituminous and modular constructions are equal.
- Examine the practicality of maintenance activity levels selected against field performance data.
- Evaluate the optimum construction/maintenance relationship using medium/long-term performance monitoring.

A major step forward would be to introduce the concept of probability wherever possible to quantify the range of uncertainty in the available data.

Figure 1, used in the original model sets out the typical maintenance profile for a bituminous construction. In this case it is possible to consider a range of maintenance treatment lives and patching needs together with a range of life cycles.

Interestingly responses to the questionnaire survey of local authorities gave an estimated average bituminous construction life of 21 years with slurry seals in the range five of five to ten years and modular construction exceeding 40 years. These compare favourably with those used in the model.

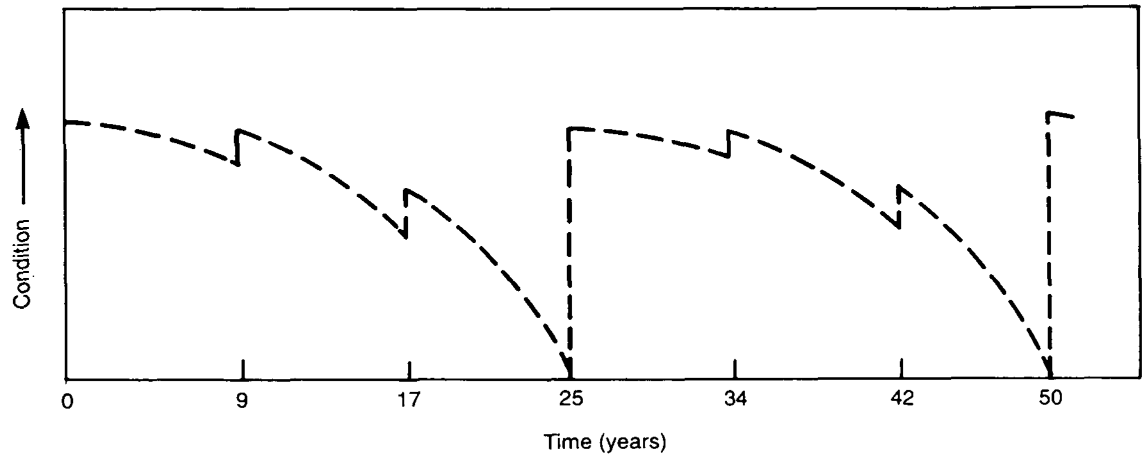


Fig. 1 Bituminous Maintenance

The diagram assumes a steady state of serviceability for the network as a whole because this may be considered to be the overall objective of maintenance. In a realistic maintenance strategy a probability of 85 per cent is adopted for road pavements and can be considered appropriate for footways until better information becomes available.

The maintenance needs assumed for this profile are:

Year	0	New construction
	25	Reconstruction
	9 and 34	Slurry seal
	17 and 42	Slurry seal + 5 per cent patching
	25 and 50	Renew blacktop

At years 25 and 50 only the bituminous layer are renewed; the sub-base is considered a perpetual material.

Similarly the fundamental assumption for modular construction assumes a constant level of maintenance activity which can be varied to evaluate various options. This is described as a relay allowance - how much would have to be re-laid annually to maintain the surface in a serviceable condition. The profile for this is shown in Figure 2.

An initial test might be a comparison of the relative probabilities of achieving an overall steady maintenance state using modular against bituminous construction. Consideration could then be given to the range of probabilities where different constructions have the same break-even cost after the costs are discounted.

5. FACTORS IN A WHOLE LIFE COST INVESTIGATION

Some of the factors constituent to a Whole Life Cost evaluation are:

1. Design
   - (i) Structural
   - (ii) Functional
   - (iii) Aesthetic/amenity
2. Construction
   - (i) Specification
   - (ii) Materials
     - Energy conservation
     - Social aspects
   - (iii) Tolerances
3. Maintenance
   - (i) Needs
     - lifespan/performance of materials
     - deterioration profiles
     - third party intervention
     - reinstateability
     - residual value
   - (ii) Intervention levels
     - economic considerations
     - social/user considerations
   - (iii) Techniques/Practices

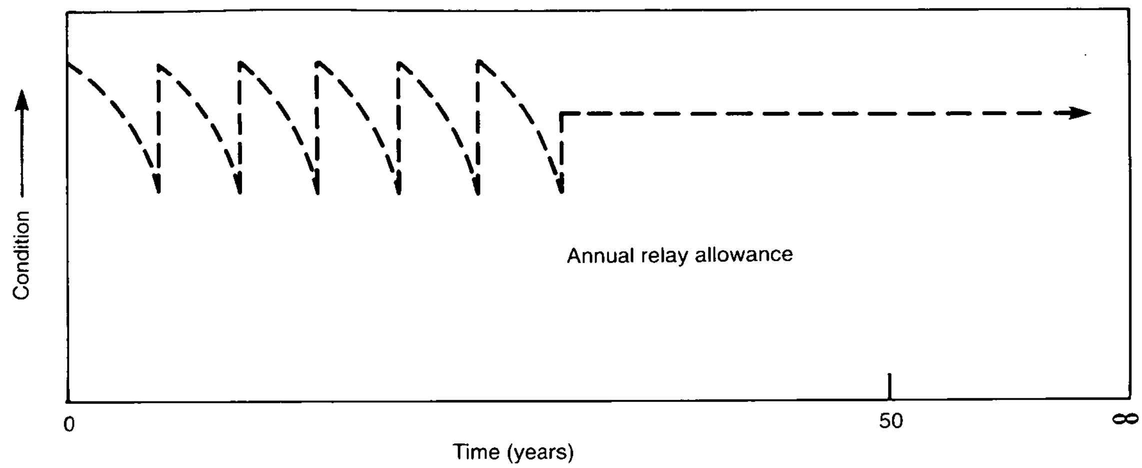


Fig. 2 Modular Construction Maintenance Profile

4. User Costs

   (i) Personal injury accidents
   (ii) Increasing user expectations

5. Inspection

   (i) Parameters
   (ii) Manual
   (iii) Mechanised

6. Prioritisation of maintenance needs

   (i) Cost/benefit

6. CONCLUSIONS

In some instances it will be possible to determine with a reasonable degree of accuracy what the costs are but substantial regional variations are expected. It is anticipated, however, once this information is available it will be possible to develop an economic evaluation of the optimum design/maintenance relationships for a variety of usage categories and materials types.

CHAPTER 8. NEEDS OF THE MOBILITY HANDICAPPED

CONTENTS

CHAPTER 8. NEEDS OF THE MOBILITY HANDICAPPED

SUMMARY

There could be as many as ten million people in the UK who suffer a mobility handicap at some time. People who would not normally be regarded as being handicapped such as those having to cope with small children, shopping or luggage should also be considered. Also included are people with long term and progressive problems associated with ageing and those with temporary difficulties such as pregnancy or the effects of an accident or illness.

This chapter gives the current position on recommended surfaces for the visually handicapped and the needs of the physically disabled are reviewed.

There is a wide range and type of mobility handicap and it is not practically possible to completely satisfy the needs of each one. The standards required by the handicapped are more demanding than those of normal, able bodied pedestrians, but their usage of footways is often very limited, due to the nature of their disability.

More research is needed to identify those areas most used by mobility handicapped people and determine the nature of the more exacting standards that will have to be applied to these areas so that the majority can be used without undue difficulty. Although these standards will be more costly to implement than those required by able bodied pedestrians, highway authorities have a duty to ensure that handicapped people are not prevented from having the same access to facilities as others. In this case, cost-effectiveness studies are not appropriate beyond an investigation to determine the maximum per cent of the disabled whose needs should be accommodated. However, a balance in the allocation of funding is needed because if funds are diverted from normal maintenance to meet disabled needs, then personal injury claims from the able bodied may increase, introducing an unacceptable level of added expenditure to the settlement of litigation claims.

1. INTRODUCTION

It is estimated that there could be as many as ten million people in the UK who suffer from a mobility handicap at some time. This includes many who would not normally be recognised as being handicapped such as those having to cope with small children, shopping or luggage. It also includes those with long terms and progressive problems associated with ageing and those with temporary difficulties such as pregnancy or the results of an accident or illness.

Finding the best place to cross the road, particularly at 'pelican' and 'zebra' crossings can be a difficult task for people with visual impairment. The crossing of large open spaces, such as pedestrianised areas, can also present problems for people with poor eyesight.

Wheelchair users and other ambulant people have problems with inadequate footpath width, lack of ramps and steep gradients. Too far to travel between bus stop or parking space and destination can also be a major problem in pedestrianised areas.

The standards required by the handicapped are greater than those of normal, able bodied pedestrians, but their usage of footways, because of the fact that they are handicapped, is unfortunately inevitably restricted mainly to town centres, shopping areas and residential areas very near to their own homes. Also, footways near primary schools will be extensively used by a large number of people whose mobility is handicapped by the presence of young children, prams and pushchairs.

Due consideration of the particular needs of the users is required when formulating intervention standards for locations frequently used by the mobility handicapped.

2. NEEDS OF VISUALLY HANDICAPPED PEDESTRIANS

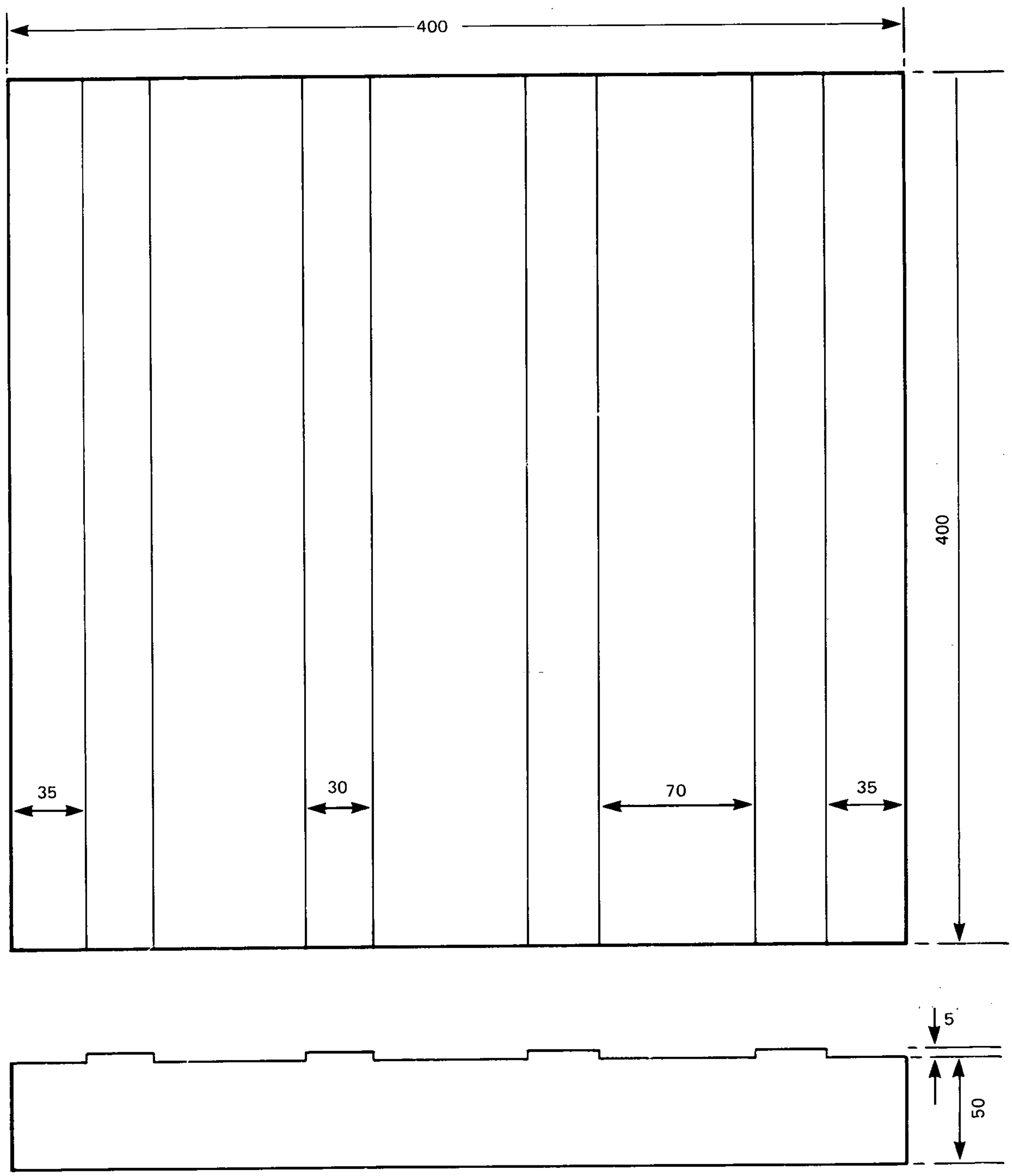
Research has been carried out at TRL and the Cranfield Institute of Technology to provide tactile markings for the guidance of visually handicapped pedestrians. Four patterns have been developed and moulded on to the surface of concrete paving. These tactile surfaces can be used to identify dropped kerbs at road crossings, as a delineator line, as a warning of an approaching hazard or the presence of an amenity such as a telephone kiosk, a public toilet or a bus stop. Advice on their use is given in Traffic Advisory Leaflet 4/90 (1990) and the Disability Unit Circular 1/91 (1991).

2.1 CYCLEWAYS

The bar pattern shown in Figure 1 can be used on shared pedestrian/cycle routes which are not segregated by level. It is laid in two directions, transverse to denote the pedestrian path, and longitudinal to denote the cycle path.

Materials have also been designed to provide a central delineator strip along the length of a shared route, providing

Profiles and dimensions of experimental tactile markings in concrete paving



All dimensions mm

Fig. 1 Cycleway Paving

a false kerb for the visually handicapped pedestrian. These take the form of 1m long rubber strips fixed to the surface with adhesive or a choice of three profiles formed from 'vibraline' thermoplastic white lining material.

2.2 HAZARD WARNING

A pattern of half rod shaped bars, as shown in Figure 2, is moulded onto concrete paving to give warning of a hazard requiring caution such as at the top or bottom of a flight of stairs, or at crossroads on a shared pedestrian/cycleway.

2.3 DIRECTIONAL GUIDANCE

This pattern of round ended bars is used to guide visually handicapped pedestrians through a large open space such as a pedestrian precinct or a town square. The bars are laid in the direction of travel, as shown in Figure 3, and are turned

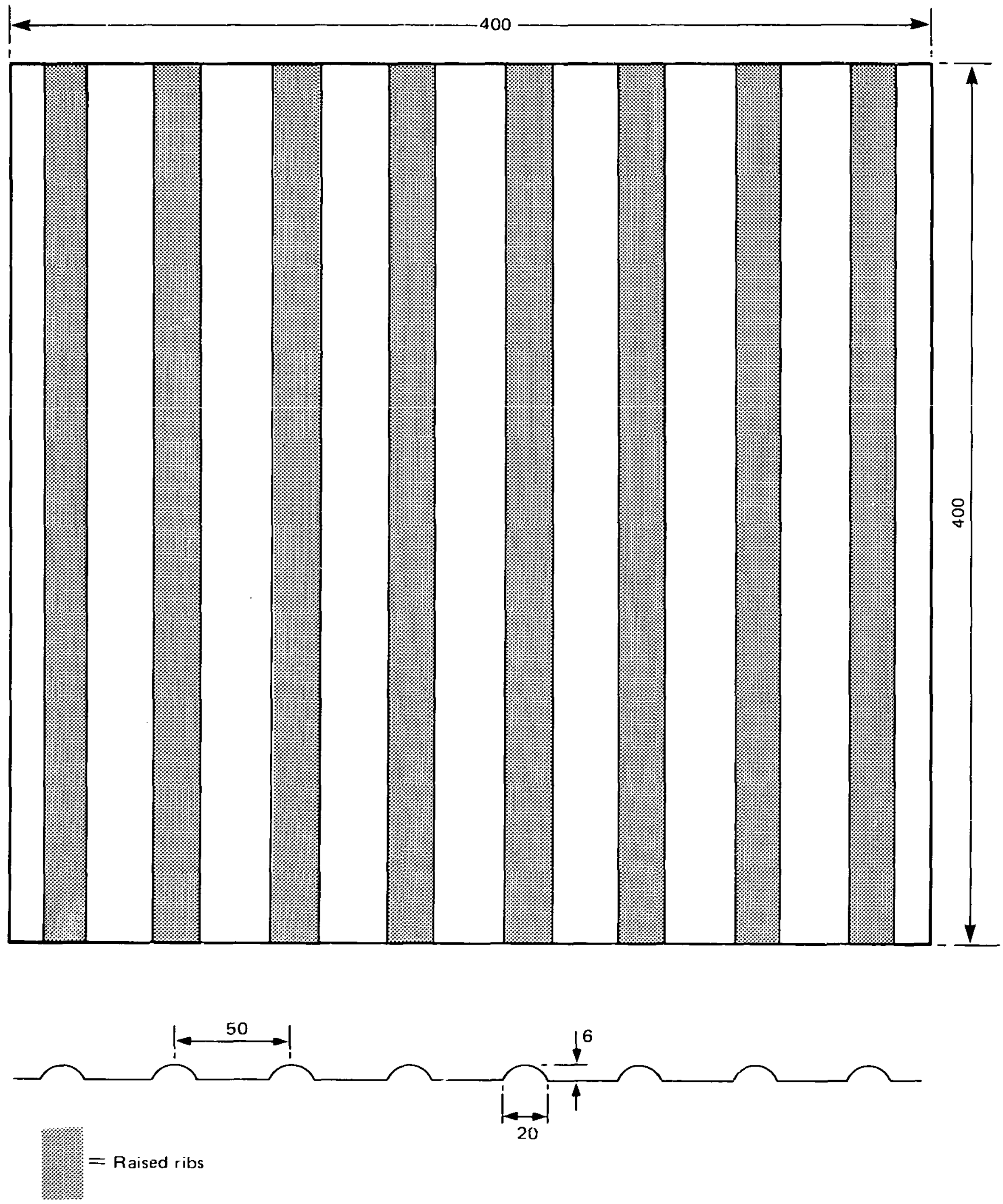


Fig 2. Corduroy Paving

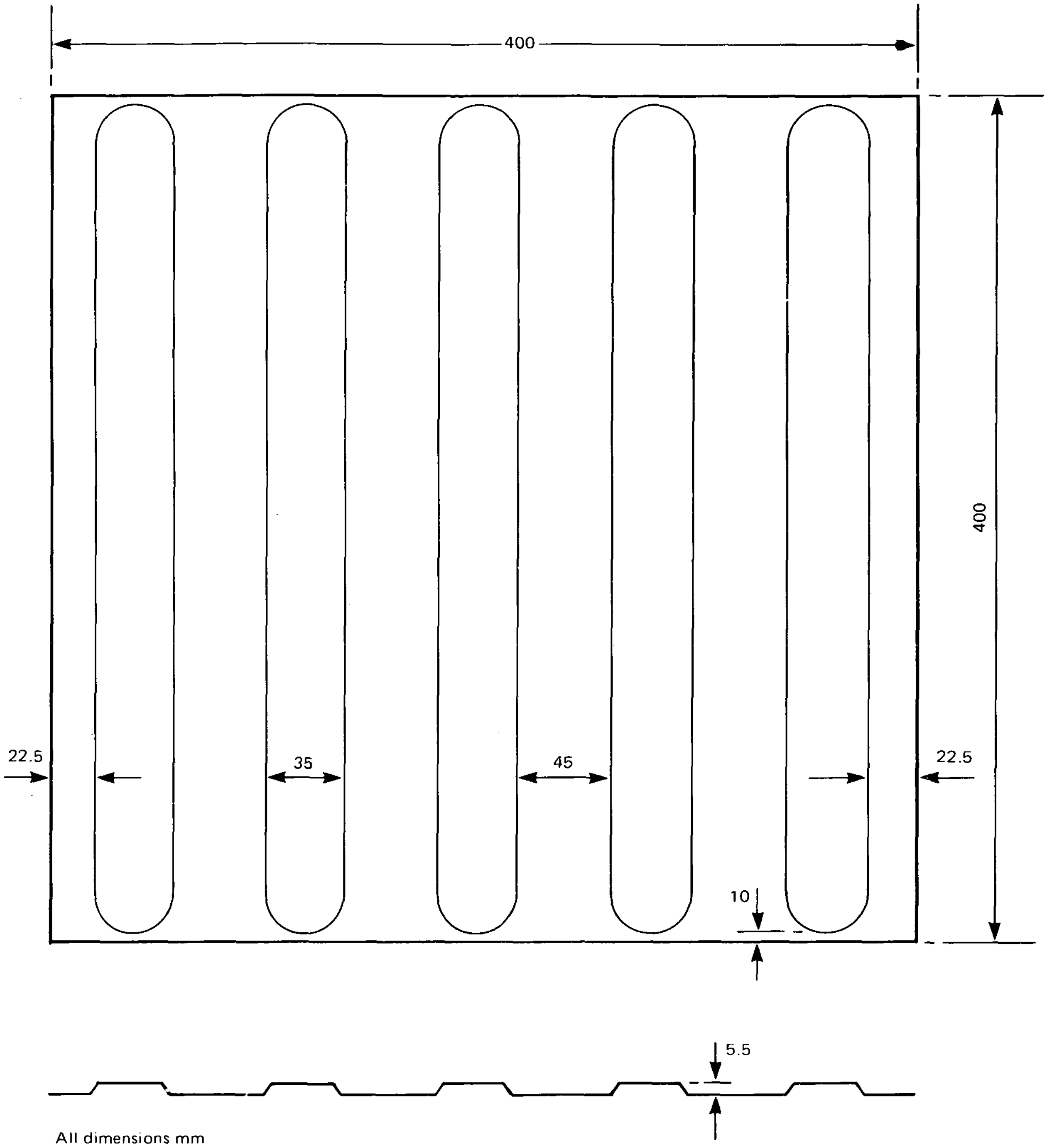


Fig. 3 Directional Guidance Paving

at corners to give warning of a change of direction. This same pattern can also be produced on rubber tiles.

2.4 SAFE CROSSING

Blister paving was developed at TRL to alert visually handicapped pedestrians to the presence of a safe crossing ('zebra' or 'pelican') where the kerb has been dropped to assist wheelchair users, mothers with prams and people with a walking difficulty. Some highway authorities received complaints that the blister pattern was uncomfortable to walk on and the Cranfield Institute of Technology produced a modified pattern, shown in Figure 4, with the tops removed from the blister domes. This pattern was tested with all user groups at Cranfield and was found to be easily detectable by blind subjects without causing discomfort to other users. This pattern is also produced on rubber tiles.

2.5 AMENITY WARNING

Trials have been conducted to find a surface with a soft or a springy feel to give a warning of the presence of an amenity such as a telephone box, public toilet or bus stop. The surface should be laid the full width of the footway and for a distance of one metre either side of the amenity. It should be inset to a 50mm depth to be flush with the surrounding surface.

2.6 PLATFORM EDGE

Rubber dot tiles, shown in Figure 5, have been produced to give warning of the edge of a railway station platform. The pattern is also available in concrete.

2.7 STREET FURNITURE

Lack of conspicuity of street furniture can be a problem for those with poor sight. It is possible to highlight all street furniture by providing them with a single white band at eye level as permitted by the Traffic Signs Regulations and General Directions. Every effort should be made to fix signs on walls instead of providing more street furniture. Similarly the tops of bollards can be painted white or yellow. Larger items of street furniture, such as litter bins, can be surrounded with tactile surfacing to identify its presence.

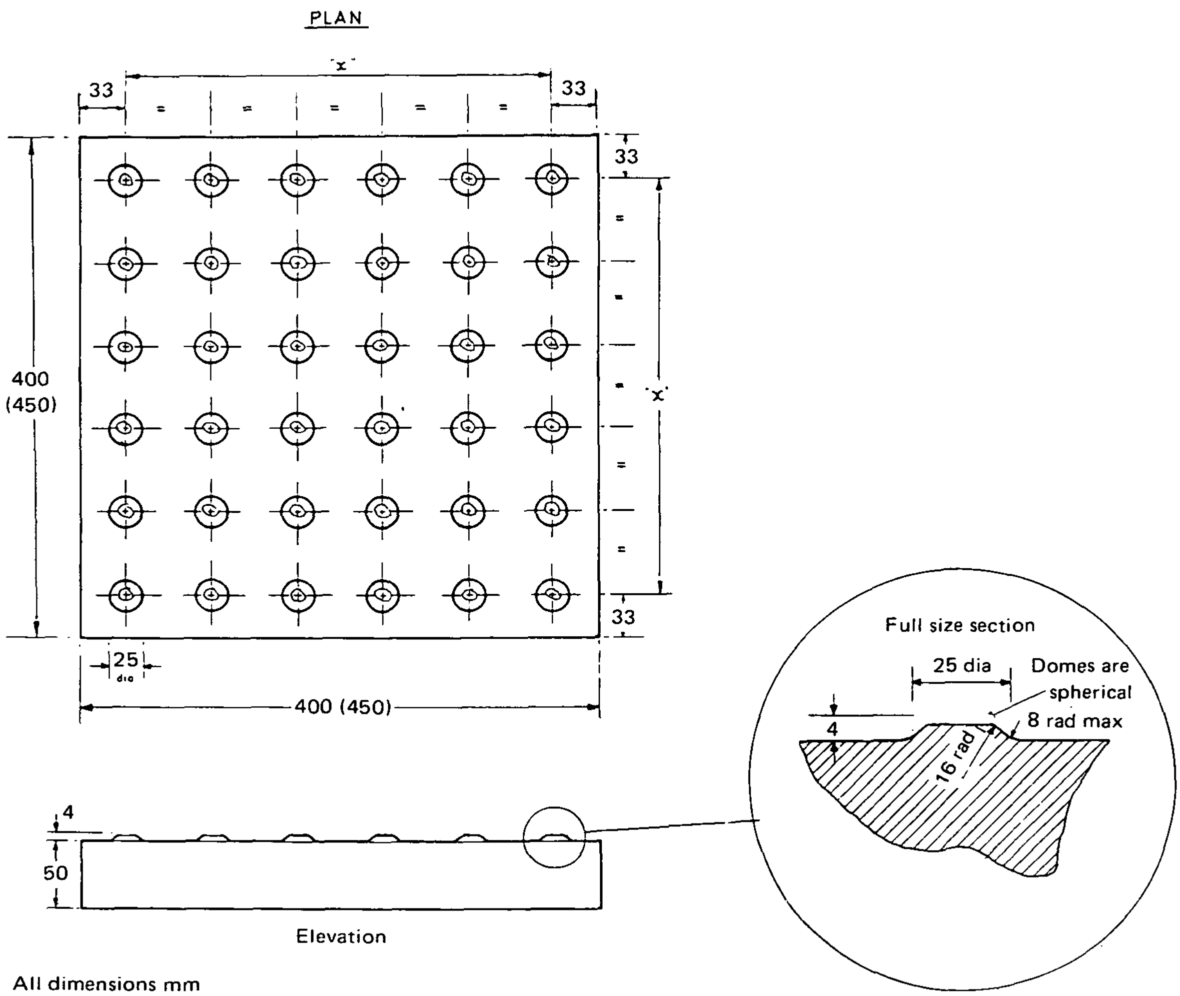


Fig. 4 Modified Blister Paving

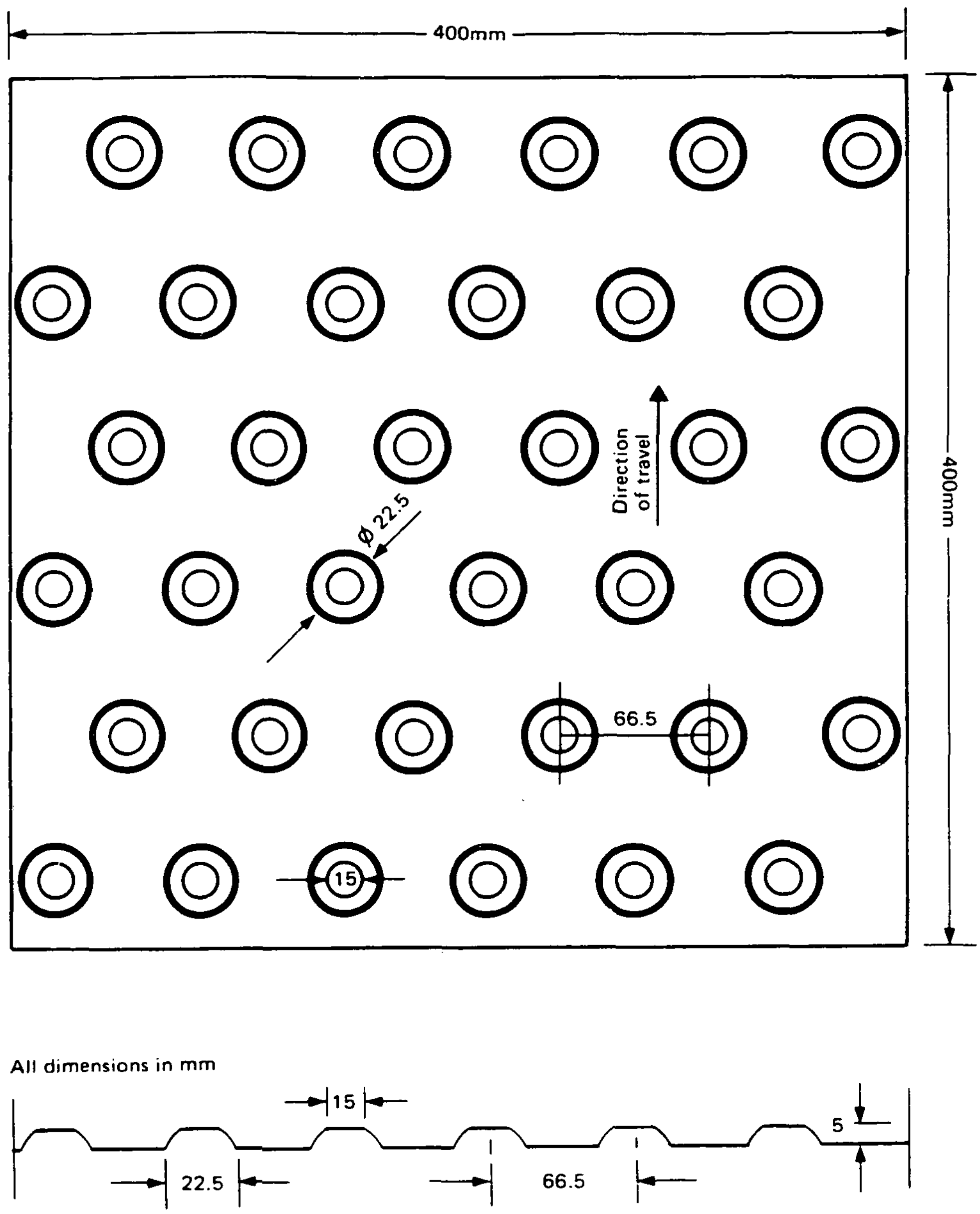


Fig. 5 Platform Edge Warning

3. NEEDS OF PHYSICALLY HANDICAPPED PEDESTRIANS

Research in the mid-1980s revealed that the benefits of accessible transport were being reduced by the difficulties disabled people had in getting about on foot or in wheelchairs. Pedestrianised town centres presented particular problems. In 1986 the Institution of Highways and Transportation published a set of guidelines, 'Providing for People with a Mobility Handicap', designed to help engineers, planners and others to reflect the needs of disabled people in the design of pedestrian areas and access by car and public transport.

The needs of the physically handicapped are the greatest amongst those who have some form of mobility handicap. Generally, if the physically handicapped can be successfully accommodated, then the needs of the physically encumbered and those suffering mental or sensory disabilities will also be met. It is important to note that different types of disability can create disproportionate mobility handicaps, and a person suffering from arthritis may have a greater handicap than a fit person in a wheelchair.

3.1 MOVEMENT DISTANCE

Research by May et al (1991) investigated the maximum movement distance that a sample of disabled people could achieve without a rest and assistance. It was concluded that the most able 80 per cent of wheelchair users and visually impaired people would require a maximum distance of 150m from a parking place or bus stop to the first destination. This maximum distance was around 100m for ambulatory disabled people without aids, and around 50m for stick users. The range is further limited by weather and speed and it is considered that a maximum time of five minutes should be used as a guideline. It is suggested that a maximum movement distance to the first destination of 100m would be required for 90 per cent of all disabled people.

3.2 GAPS BETWEEN PAVERS

It was concluded that, in the interest of ambulatory disabled people, design and maintenance should aim to avoid gaps greater than 10m wide with a total length of more than three metres for each five metre by two metre area. Small element block paving appeared to produce less concern than footways constructed from large pavers.

3.3 SURFACE IRREGULARITIES

There was some evidence to suggest that height differences between actual surface and surrounding surface should not exceed 5mm. It can be concluded that design and maintenance techniques should avoid mean undulations or irregularities of more than 5mm. This is a very demanding requirement and can probably only realistically be met in areas extensively used by physically disabled people.

3.4 FRICTION

There are conflicting requirements by different users for the level of friction. Stick users require a high coefficient of friction whereas wheelchair occupants require a low level to reduce the amount of effort required to move around. Some ambulatory pedestrians could, because of their disability, drag their feet when walking, and experience difficulties when encountering high values of friction. There could also be problems on smooth wet surfaces for all pedestrians.

The use of the TRL Portable Skid Resistance Tester to measure the coefficient of friction is not the best method because the device was designed to model the contact between a vehicle tyre travelling at 50km/h and the road surface. More research is needed to determine the importance of using a good skid resistant surface and the most appropriate method of measurement.

3.5 GRADIENT

Wheelchair users have been found to experience greatest difficulty on sites having gradients greater than +2 per cent or -6 per cent. Ambulatory disabled pedestrians experienced difficulty on sites of greater than +4 per cent and -6 per cent. It was also concluded that all slopes longer than 30m could cause difficulties to wheelchair users.

Inevitably the topography of some sites means that a positive gradient experienced when travelling in one direction becomes negative when travelling in the opposite direction. Where movement is expected in both directions along a gradient the more stringent threshold should be applied if at all possible.

3.6 CROSSFALL

It was found that some wheelchair users and ambulatory disabled people had difficulty in coping with crossfalls greater than 1 per cent. However a crossfall of 2 per cent is required to provide adequate water drainage and so it is argued that crossfalls should never exceed this value of 2 per cent.

3.7 FOOTWAY WIDTH

It is considered that the minimum width of footways should be 1800mm to allow a wheelchair and pram to pass each other. The absolute minimum width at local restrictions or obstacles should be 900mm.

3.8 DRAINAGE

All users have problems with surface water. The problems are emphasised for those with mobility and physical handicaps and it may be necessary to carry out footway inspections during wet weather to identify areas of ponding.

3.9 CROSSING THE ROAD

Dropped kerbs are provided at junctions to assist those with mobility handicaps. Tactile surfaces are provided at 'pelican' and 'zebra' crossings to aid people with visual impairment to locate safe crossing points. The traditional 40mm upstand on dropped kerbs can cause discomfort to wheelchair users and some highway authorities consider it desirable to have no upstand; the top of the kerb should be flush with both footway and carriageway.

3.10 SIGNING

Good signing can help the mobility handicapped by advising other users that the route is used by vulnerable disabled pedestrians or wheelchair users. Signs can also be used to advise those with mobility handicaps of routes to key destinations by using the disabled symbol on the most suitable route where several exist. It is suggested that opportunities should be taken to provide scented plants and shrubs with textured leaves in parks and gardens.

4. RANGE AND TYPE OF HANDICAP

There is a very wide range and type of mobility handicaps and unfortunately it is not practically possible to provide footways to completely satisfy the needs of each and every one. However, highway authorities should do everything that they can within the limitations of their resources to ensure that the majority of the mobility handicapped can have access to as many facilities as possible. Decisions will have to be made on the likely usage of footways by the mobility disabled, what their needs are and the likely cost of meeting them. The study by May et al (1991), considered the minimum requirements to be met to provide for 80 per cent of those in each group of a number of disabilities as shown on Table 1 below.

5. FUTURE RESEARCH

Little has been done to relate the obvious and deserving needs of the mobility handicapped for higher standards of design and maintenance to their usage of footways and the increased cost of providing these higher standards.

Is the incidence of personal injury higher amongst the mobility handicapped or is it perhaps very low because many handicapped people are prevented from using footways because of their poor standard of repair or unsuitable design?

More research is needed to identify areas most frequently used by the mobility handicapped; more exacting standards will then have to be applied to these areas so that the majority of the handicapped can use them without undue difficulty. The very fact that they are handicapped makes movement difficult under any conditions, but it is the duty of every highway authority to ensure that these people are not prevented from having the same access to facilities as that enjoyed by the able bodied.

Organisations representing the mobility handicapped need to be consulted to identify problems and practices which might present difficulties for their members.

Research is needed to confirm the findings of May et al (1991) over a wider range of footways and subjects. More exacting standards will then have to be applied to the areas identified as those most frequently used by the mobility handicapped so that the majority can be used without difficulty. A less demanding standard can be applied to the remainder of the network where the usage is predominantly by able bodied pedestrians.

TABLE 1

Summary of minimum requirements

	Distance (m) (1)	Gaps (m) (2)	Surface Irregularity (mm) (3)	Friction Coefficient (4)	Gradient Up (%)	Gradient Down (%)	Gradient Length (m) (5)	Crossfall (%)
Wheelchair bound	160	5	5	nk	2	6	30	2
Visual Impaired	160	5	5	nk	nk	nk	nk	nk
Ambulatory Disabled (stick users)	50	3	4	35	4	6	nk	2
Ambulatory Disabled (no aids)	100	3	5	35	4	6	nk	2
Elderly	nk	10	8	nk	nk	nk	nk	nk
Able Bodied	nk	10	nk	nk	nk	nk	nk	nk

Notes:
(1) Maximum distance (m) without a rest
(2) Length of gaps >10mm wide per 2m x 5m rectangle
(3) Mean absolute difference (mm) from hypothetical 2m x 5m plane
(4) Minimum, measured using TRRL Portable skid resistance tester
(5) Length of gradient (m)
nk Not known. Outside the ranges tested in the study

6. CONCLUSIONS

There is a wide range and type of mobility handicap, and it is not practically possible to completely satisfy the needs of each one because the standards required by the handicapped are more demanding than those of the able bodied.

Further research is needed to identify those areas most used by mobility handicapped people and determine the nature of the more exacting standards that will have to be applied to these areas so that the majority can be used without undue difficulty.

CHAPTER 9. CURRENT FOOTWAY RESEARCH IN THE UK

CONTENTS

CHAPTER 9. CURRENT FOOTWAY RESEARCH IN THE UK

SUMMARY

There is little current research being undertaken to improve footway condition, the overall performance of footways or the efficient use of maintenance funds, despite the estimated annual £300 million cost of footway maintenance representing some 14 per cent of the total UK annual expenditure on highway maintenance.

In 1977 the Standing Committee on Highway maintenance carried out a study into the technical and financial aspects of footway maintenance. This resulted in an increased understanding of the need for an efficient maintenance management policy and means of identifying defective areas with associated realistic and easily understood intervention criteria.

The Working Party on Highway Research set up a Footway Maintenance Working Group in 1991 to address all aspects of footway maintenance, including the identification of areas where research may be needed.

The new Highway Authorities and Utilities Committee Specification requires the accurate measurement reinstatement profile against clearly defined criteria. The requirement of the Department of Transport Routine and Winter Maintenance Code and the Local Authority Associations' Code of Good Practice have also encouraged a more quantitative assessment of footway condition.

Recent research has led to the provision of an end product/ performance specification for a footway profilometer and a design guide for footway construction is currently being drawn up. Other areas of future research being reviewed include, warning and intervention levels, whole life costing, performance of cold-laid materials, hot and cold recycled materials, problems associated with vehicle overrun, tactile markings and surfaces to aid the mobility handicapped and compaction equipment for use on footways where manoeuvrability is restricted.

1. INTRODUCTION

In recent years footway problems have had little research despite being a major part of urban highways and residential areas. In the urban environment footways can represent over 20 per cent of the capital value of a highway. In the metropolitan authorities the cost of footway maintenance represents about 14 per cent of the annual highway maintenance expenditure. This figure can be as high as 23 per cent in the London Boroughs.

The introduction of the HAUC Specification will also have a significant effect on the condition of the footway. Training for street works operatives in reinstatement techniques commenced in April 1992 over a 5 year period.

The increasing cost of maintaining footways is highlighting the need for further research into design, construction and maintenance requirements including an assessment of the cost-benefits of surface treatment versus reconstruction.

2. STANDING COMMITTEE ON HIGHWAY MAINTENANCE (SCHM) REPORT

"A study of footway maintenance 1979-80"

In 1977 the Standing Committee on Highway Maintenance instigated a research programme into the technical and financial aspects of footway maintenance. An important objective of the report was the achievement of a greater appreciation of how and why resources for footway maintenance are used in the way they are. In addition, it was hoped that the study would provide information, for the benefit of highway authorities and others, about the scope of improved management in terms of techniques used and policy, including improved cost-effectiveness."

A comprehensive investigation was undertaken, in four study areas, to examine all aspects of footway maintenance work. There were four main recommendations:

1. A scale of common condition levels should be defined on which authorities can assess the condition of their footways.

2. The examination of alternative methods for increasing the cost-effectiveness of such major maintenance work should be considered for further research.

3. The cost-effectiveness of alternative mechanised maintenance methods should be investigated to minimise costly labour intensive methods.

4. Provision of small-scale publicity to reduce overrun. A study of the cost-effectiveness of edge strengthening at sites that suffer overrun should be undertaken.

3. PERFORMANCE OF SURFACING MATERIALS

To date there has been no significant research into the performance of footway surfacings. However, some work has been undertaken in respect of cold-laid materials and propriety mixes such as Fibrescreed. Other research has been undertaken on recycled materials and remix processes for highway pavements. These research findings could also be applicable to footways.

3.1 COLD-LAY MATERIALS

The problem with the cold mixes currently available is that they only have about one third of the stiffness of hot mixes. British Gas Plc have undertaken some trials, on highway pavements, with cold-lay materials for trench reinstatements in collaboration with Lothian Regional Council Highways Department. The main objective of these trials was the evaluation of the in-service performance of ten commercially available surfacing materials, including graded and asphaltic materials, using both emulsified and cutback binders. A collaborative research project with a major UK producer of bituminous bound material has also commenced. The objective of this work is the rational design and site evaluation of emulsion-based bituminous bound materials.

In an informal collaborative project between Heriot-Watt University and British Gas Plc, a laboratory test has been developed to measure the compatibility of cold-lay materials. Further work to measure the accelerated ageing procedures for cold-laid materials using emulsified petroleum bitumen binders is being undertaken.

The Footway Maintenance Working Group have undertaken trials of cold-lay bituminous materials for footways in collaboration with Leicestershire C C, Evered Bardon Plc and Northamptonshire Engineering Service Laboratory. Two typical sites were selected; a conventional suburban residential estate and an urban location where the footway was subjected to significant levels of vehicular traffic. Trial holes were taken to establish sub-base thicknesses and in-situ CBR values and plate bearing tests were carried out on the newly compacted sub-base. All materials were sampled and tested for grading and composition. Cores were taken for density testing and also for NAT stiffness tests. Surface deformation is being monitored at 3 monthly intervals.

4. HOT RECYCLED MATERIALS

TRL have carried out research on in-situ hot mix recycling (repave and remix) of HRA wearing courses, cold in-situ recycling of roadbase using foamed bitumen and hot-mix offsite recycling of HRA roadbase, basecourse and wearing course and DBM roadbase. Work is also underway on the use of recycled bituminous materials for use as a sub-base.

The outline of the research projects is given below. The research findings would be relevant to the use of recycled materials for footways.

4.1 RECYCLED ASPHALT WEARING COURSES

Edwards and Mayhew (1989) showed that HRA wearing courses recycled, in-situ using the remix, repave or off-site processes performed equally as well as new material for pavement construction. Assessment of costs in material production were made and there was a saving in energy used which was greater in hot weather.

4.2 ASSESSMENT OF THE PERFORMANCE OF OFF-SITE RECYCLED BITUMINOUS MATERIAL

Research by Cornelius and Edwards (1991) showed that:

1. Recycled DBM roadbase manufactured by a pilot scale plant had an elastic modulus, fatigue resistance and resistance to rutting similar to virgin material.
2. HRA roadbase and basecourse material containing up to 60 per cent recycled material, manufactured and laid by full-scale plant, performed better than virgin material when the above laboratory tests were carried out, and after four years in-service they performed as well as virgin material.
3. A 30 per cent saving in material cost and some saving in energy use could be obtained.

4.3 REMIX SPECIFICATION TRIALS: CONDITION AFTER ONE YEAR

A series of specification trials were carried out during 1990/91 using the remix process on full-scale maintenance works under standard contractual conditions. The early findings suggest that there is no problem in producing or laying the material to comply with specification for new HRA wearing course. After one year the in-service performance is satisfactory.

4.4 GENERAL CONCLUSIONS

All the research currently undertaken on the use of hot-mixed recycled material for highway pavements suggests that the material performs as well as new material provided that the recycled materials comply with specification for new materials.

These areas of current highway research should be applicable to footways.

5. COLD RECYCLING

5.1 FOAMED BITUMEN

Research undertaken by TRL for commercial firms on foamed bitumen recycled roadbase material is classified as commercial in confidence. The in-service performance of the material appears to be satisfactory but problems have been encountered in obtaining samples for laboratory testing because the material disintegrates while being cored. It is also not yet clear whether the standard laboratory tests for bituminous materials are applicable to this material or whether those used for unbound or cement-bound would be more appropriate.

5.2 SUB-BASES

TRL have carried out a trial using bituminous material as sub-base. The bituminous material has been stockpiled from excess hot mix material and left to cool. Initial research findings suggest that the material is similar in performance to Type 1 sub-base. This work is continuing.

6. FOOTWAY CONSTRUCTION TRIAL

An investigation into the problem of footway damage and repair was undertaken by the Department of the Environment (Northern Ireland) in 1986/87. Nineteen test bays were constructed within a 60m length of footway, 1.5m wide, using 300 x 150mm concrete kerbs to provide edge restraint. The materials used in the test footways included HRA surfacing, 100mm and 150mm concrete slabs, 60mm concrete paving setts and DBM surfacing. The test footway was trafficked by vehicles and their axle loadings recorded by an axle weigh pad located near the start of the test footway.

The conclusions and recommendations are summarised in Chapter 1, Methods of Management, and are of interest to Engineers when planning footway reconstruction and maintenance schemes.

7. STABILISATION OF JOINTING SAND

The article 'Stabilisation of jointing sand in block paving' by J A Emery published in the Journal of the Institute of Highways and Transportation (1991) examines the most effective means of preventing erosion problems in block paving. It concludes that the most effective material is a specially formulated liquid pre-polymer which retains elasticity after curing and is thus able to sustain the essential flexible nature of the block paving surface.

8. PEDESTRIAN PREFERENCES

Attitudinal surveys of pedestrians were conducted at 13 sites in Sheffield in 1989, representing four different types of paving and a range of surface qualities. The main problems identified were undulation, raised edges, slipperiness, broken pavers and gaps. Clear preferences were identified for small element paving on aesthetic grounds and for small element paving with pencil arris, and for some types of blacktop, in terms of ease of use. The work is reported in an article 'Pedestrians Preferences for Footway Maintenance and Design' by G R Leake et al in the Journal of the Institute of Highways and Transportation (1991).

9. TACTILE MARKINGS AND SURFACES FOR THE BLIND

9.1 TACTILE MARKINGS

A research study is being undertaken at TRL to develop tactile markings which will enable blind and partially-sighted pedestrians to locate themselves on the correct side of shared cyclist/pedestrian routes. A number of papers have been published on this topic, they are reviewed in Chapter 8.

9.2 TACTILE SURFACES

In November 1988 TRRL commissioned the Centre of Transport Studies, Cranfield Institute of Technology, to carry out research to determine how many different surfaces can effectively and reliably be distinguished by visually handicapped people.

Among the recommendations of the report are that a latex surfacing should be used for information e.g. access to a bus stop, a rubber/concrete bar Pathfinder should be used for guidance e.g. through a pedestrian area and a modified version of DOT blistered paving should be used to warn of dropped kerbs at road crossings. The wear characteristics of these surfaces are not yet known. The effects of weather, particularly frost and snow, need to be considered, as does the ability to withstand street cleaning equipment. The whole topic of appropriate layout needs to be examined.

The recommendations from this report should be considered when the research into design, construction, materials and techniques is formulated.

9.3 OTHER PUBLISHED REPORTS

Two other interesting reports associated with mobility handicaps have been published recently:

Revised guidelines for: reducing mobility handicaps towards a barrier-free environment. August 1991 Institute of Highways and Transportation.

Ergonomic requirements of pedestrian areas for disabled people. Contract report 184, 1991, Leeds University.

10. FOOTWAY DESIGN GUIDE

The fundamental principle of the guide for the Design of Footways produced by National Paving & Kerb Association (NPKA 1991) is the evaluation of the thickness and type of sub-base to be used beneath flags. The damage caused to footways by vehicle overrun has been recognised for many years. The research undertaken by NPKA was sponsored and funded by Science and Education Research Council (SERC) and NPKA under the control of J Bull of the University, Newcastle Upon Tyne. The research studied the interrelationship between the loading conditions imposed on paving flags, the basic flag properties and the physical properties of the pavement foundation. It included a computer based analytical investigation using finite element analysis, laboratory testing of paving flags on various bedding materials, and four test sites. New research undertaken by Al-Khalid of the University of Liverpool, has also been included in the guide. Further information on the subgrade bearing stress, obtained by both researchers, relates to the influence of load repetitions and the wheel configuration i.e. single or double tyre wheel.

There is a need to provide a comprehensive Design and Construction Guide for footways incorporating existing practical knowledge and further research in associated areas to be identified by the Footway Maintenance Working Group.

11. PROFILE MONITORING EQUIPMENT

Monitoring equipment to measure the profile/trips of footways.

Some time ago the DOT and the County Surveyors' Society recognised the need to measure the settlement/profile of trench reinstatements in the highway to support the HAUC Specification.

Research was commissioned in 1992 by the Working Party on Highway Research to examine and evaluate methods of identifying and measuring a range of footway defects. A Profiler Subgroup was set up to oversee the research involving trials with two profile measuring machines to produce a generic end product/performance specification for a Footway Profilometer. Readings from one of the machines have been tested against pedestrian's subjective reactions.

A literature review by Spong (1994) found that of the 25 existing devices examined, two had the most potential of satisfying the requirements of a provisional specification. These were the British Gas Road Profile meter and the WDM Footpath Profiler.

Results of a series of tests on in-service footways and artificial surfaces by Spong and Cooper (1994), demonstrated the suitability of the two machines for the assessment of footway profiles. Objective measurements of footway profile were compared with the subjective impressions of footway serviceability using a sample of pedestrians at four sites.

It was concluded, that although more work was needed to establish reliable maintenance intervention levels the research results could be used to obtain an end product/performance specification for a footway profilometer that could be used by a manufacturer. The Specification is described in a second report by Spong and Cooper (1994).

Future research in this field is planned and proposals have been drafted for work on intervention levels, pedestrian subjective impression and Whole Life Costing. It is hoped that the future research will be jointly funded by the County Surveyors' Society (CSS), the Department of Transport Highways Agency (HA) and the European Union (EU).

12. RESEARCH IN COLLABORATION WITH INDUSTRY

Discussions were held with JCB Excavator Company and Bomag (UK) regarding the development of suitable compaction equipment for use in restrictive conditions, particularly on footways. JCB launched a new range of mini-backhoe excavators early in 1991 and are examining ways of improving the range of attachments. The design of a plate compactor to comply with Chapter 8 of the Traffic Signs Manual in terms of narrow operational widths appears to be one potential solution.

Recent discussions with the Slurry Seal Contractors' Association (SSCA) has led to an interest in carrying out footway trials with their products and the development of new materials for footway use.

13. CONCLUSIONS

There is little current research being undertaken to improve footway condition. Recent research has led to the provision of a generic end product/performance specification for a footway profilometer and a design guide for new footway construction (phase 1) is being drawn up. A design guide for maintenance of footways (phase 2) will be undertaken during 1995/96.

The survey of highway authorities identified several areas where more research is needed. These include the needs of the mobility handicapped, warning and intervention levels, whole life costing, the performance of cold lay materials, hot and cold recycled materials, problems associated with vehicle overrun and compaction equipment for use on footways where manoeuvrability is restricted.

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ANNEXE

SUMMARY OF MAIN FINDINGS FROM QUESTIONNAIRE SURVEY

The responses from each Local Authority or Central Government Source have been grouped together under the following headings:

A. CAUSES OF FOOTWAY PROBLEMS

B. MATERIALS AND REPAIR TECHNIQUES
   (a) Bituminous materials
   (b) Slurry seal surfacing
   (c) Surface dressing
   (d) Concrete
   (e) Blocks, Flags and Setts
   (f) Sub-bases
   (g) Recycled materials
   (h) General

C. MONITORING EQUIPMENT AND TECHNIQUES

D. WARNING LEVELS AND INTERVENTION CRITERIA

E. WHOLE LIFE COSTS

F. DESIGN AND CONSTRUCTION

G. METHODS OF MANAGEMENT

Note: Not all the authorities surveyed responded to each question in the questionnaire.
Full details are available from TRL.

A. CAUSES OF FOOTWAY PROBLEMS

A.1 Percentage of footway network dominated by traffic conditions rather than environmental requirements.

Network area	Percentage	No. of responses
Overall	5	1
	6	1
	20	1
	30	1
	50	1
	60	2
	70	3
	75	1
	85	1
	90	7
	95	2
Urban	70	2
Rural	10	2

A.2 Materials used for initial construction and maintenance.

Materials	No. of Responses
Bituminous materials	30
Concrete	2
PCC flags	22
Concrete blocks	26
Clay pavers	11
Natural stone paving	2

A.3 Techniques for minimising footway damage.

Description	No. of responses
Prevent/deter overrunning	19
Strengthen footway design and/or construction to accommodate overrunning	14
Provision of bollards, guard rails, trees, etc.	8
Educate drivers about overrunning	2
Enforcement to prevent footway parking	3
Maintain full 125mm kerb face	1
Make it illegal for vehicles to cross footway unless licensed	1
Greater use of small element modules to withstand overrunning	4
Encourage use of in-situ concrete where no services	1
Use of durable materials	1
Provision of double kerbs and 'Trief' kerbing	1
Ensure proper and effective supervision at construction stage	5
Minimise damage caused by Statutory Undertakers - tighter spec etc.	10
Provision of sufficient funding to permit necessary maintenance to be carried out	1
Maintain with adequate treatment	2
Routine inspections to recognise potential problems	1
Encourage provision of off-street parking	3
Use footway cleansing vehicles that cause less wear and tear	1
Increase kerb face	4

A.4 Percentage of footway budget spent on faults in the following categories.

Faults	Average no. of responses
Poor design and/or specification	18
Faulty construction	11
Abuse	25
Weathering	15
Fair wear and tear	21
Damage by vegetation	5
Perceived failure	5

A.5 Other significant causes of footway maintenance problems.

Problem	No. of responses
Footway suction cleaners	3
Longitudinal cracking	1
PUSWA activity	1
Slippery surfaces	1
Drying out of clay subsoils	1
Theft of stone flags	1
Mining subsidence	1
Loss of kerb face from carriageway resurfacing	1
Springs	1
None	20

B. MATERIALS AND REPAIR TECHNIQUES

a. Bituminous Materials

B.a.1 Specified bituminous basecourse and surfacing materials.

Materials	No. of Responses
Dense roadbase	-
Open graded basecourse	7
Dense macadam basecourse	26
Single course	2
Fine graded wearing course	6
Medium graded wearing course	15
Dense wearing course	19
Open graded wearing course	-
Close graded wearing course	3
RA basecourse	-
RA wearing course	12

B.a.2 Concern about texture and skidding resistance of footways.

Is there concern?	No. of responses
Yes	18
No	11

B.a.3 Problems encountered with materials.

Problem	No. of responses
6mm dense bitmac w/c failure	2
Closetex will not take traffic	1
Minor problems with deferred set	3
Reinstating red asphalt	1
Hot materials laid in cold weather	2
Accelerated weathering of w/c	1
Open graded materials with soft bitumens	1
Macadam with fluxing oil	1
FCA mixed at too high temperature	1
Open texture materials and sealing grit unpopular	1
6mm materials difficult to lay against kerbs and edgings	1
6mm dense w/c laid 20mm thick	1
Basalt aggregate does not last as long as limestone	1
Deferred set materials - deformation under loading	2
10mm close graded difficult to lay in thin layers	1
Cut back materials did not set	1
None	9

d. Concrete

B.d.1 Use of foam mortar/concrete in trench reinstatements.

Is foam mortar/concrete used?	No. of responses	Is the performance satisfactory?	No. of responses
Yes	13	Yes	6
		Not entirely	1
		Material satisfactory, application poor	2
		Some cracking, material not sufficiently porous	1
No	17	-	-

e. Blocks, Flags and Setts

B.e.1 (i) Specified dimensions of flags selected from list of nominal sizes.

Nominal Size (mm)	Thickness (mm)	No. of responses
600 x 450	50	2
	63	3
600 x 600	50	8
	63	8
600 x 750	50	2
	63	4
600 x 900	50	8
	63	10
450 x 450	50	4
	70	10
400 x 400	50	7
	65	7
	80	3
300 x 300	50	2
	60	1
	75	1

(ii) Reasons for use of small element paving.

Reason for use	No. of responses
Aesthetic grounds	5
Better performance than traditional flags	5
Both of the above reasons	14

B.e.2 **Problems with joints in flags/blocks.**

Problems	No. of responses
Loss of sand/cleaning vehicles/water	11
Poor reinstatement by Utilities	4
Weed growth	2
Workmanship	1
In heavily trafficked zones	1
Movement of small cut blocks	1
Edge spalling	1
Unrestrained edges	1
Matching imperial/metric	1
Joints at radii require mortar	1
Mechanical failure	1
Debonding of joint	1
None	7

B.e.3 **Problems encountered with mortar bedding.**

Problems	No. of responses
Weeds	1
Suction sweepers	1
Insufficient quantity laid	1
Others	1
None	21

f. Sub-bases

B.f.1 **Specified sub-bases.**

Specified sub-base	No. of responses
Type 1 Sub-base	26
Type 2 Sub-base	10
Type 3 Sub-base (local spec)	1

B.f.2 **Adequacy of sub-base materials.**

Are materials adequate?	No. of responses
Yes	27
No	1
Occasional segregation problems	1

h. General

B.h.1 Availability of relevant information on performance of footway materials or treatments.

Do you have any relevant information?	No. of responses	Can it be made available?	No. of responses
Yes	2	Yes	1
In progress	1	No	1
No	27	-	-

B.h.2 Preferred surfacing material.

Possible material	No. of responses
6mm dense bitmac w/c	10
Bituminous	3
Depends on area	3
DBM outer areas, flags and blocks inner	3
6mm medium textured w/c	2
Rolled asphalt	1
Modular paving	1
10mm dense bitumen Wardtite	1
Other	1
None	5

B.h.3 Dissatisfaction with performance of footway surfacings.

Dissatisfaction with surfacings	No. of responses
Mori poll shows dissatisfaction	1
Premature failure due to cold materials	1
Other	1
No dissatisfaction	23

B.h.4 Type of significant problem with footway materials.

Problems with footway material	No. of responses
Poor delivery of bituminous materials	1
Length of time to lay and compact bituminous materials	3
Vehicle overrunning	2
Mechanical cleansing	1
Trench openings	1
Deferred set materials	5
Mastic asphalt slippery and difficult to reinstate	1
Medium texture w/c tends to be open texture	1
Hot materials present difficulties in cold weather	1
Early weathering if little used	1
600mm x 900mm flags	1
Thin slurry seals make underlying layers brittle	1
Faulty manufacture of FCA	1
Footways not to specification	1
Surface dressing - complaints from public	1
Flags	2
No significant problems	12

B.h.5 Is there a need for a more rigorous/restricted specification for footways?

Is this specification needed?	No. of responses
Yes	13
No	13

B.h.6 Areas where improvements can and should be made.

Area needing improvements	No. of responses
Site supervision	3
Improved compaction specification	4
Continuing research	1
Hot boxes and lorry heaters	1
Workmanship	1
Hard edges behind kerbs	1
Reinstatements	1
Improved design	1
Co-ordination of trials	1
End product specification	1
Low temperature bituminous materials	1
Training of flag layers	1
None	11

C. MONITORING EQUIPMENT AND TECHNIQUES

C.1 Use of equipment to measure defects such as profile, settlement and trips.

Is equipment used?	No. of responses	Type of equipment used?	No. of responses	Indication of accuracy?	No. of responses
Yes	12	Camera	1	Coin or credit card	1
				1mm	1
		Gauge, tape, straight edge, etc.	10	5mm	1
				To MARCH criteria	1
Only claim sites	2	-	-	-	-
No	16	-	-	-	-

C.2 Is there a need for equipment to measure settlement on trench reinstatements in support of the New Roads and Street Works HAUC Specification?

Is there such a need?	No. of responses
Yes	21
No	8
Don't know	1

C.3 Monitoring equipment designed for footway/carriageway use.

Which type of equipment would be useful?	No. of responses
Hand held	15
Hand held and towable	6
Towable	1
Push/pull	1
Don't know	2
None	1

C.4 Equipment for measuring structural integrity and user perceived faults in footways.

Which type of equipment would be useful?	No. of responses
Ground probing radar	1
Equipment for measuring trips and depressions	2
Coring	1
Modified FWD	1
Skid tester	1
Modified carriageway equipment	1
Equipment for measuring depths after laying	1
Public survey to measure perceived faults	1
Don't know	5
Could not justify cost	1
Question is irrelevant	2
None	8

D. WARNING LEVELS AND INTERVENTION CRITERIA

D.1 Numbers of trips and rocking flags identified on footways in urban and rural environments:

No. of trips and rocking slabs	No. of responses
140	1
312	1
1,040	1
10,000	1
20,000	1
261,120	1
500,000	1

D.2 How might warning levels and intervention criteria be made more objective?

Possible ideas	No. of responses
MARCH/LAA code	9
Greater priority to bituminous footways	1
Public consultation	1
Present criteria satisfactory	3
Criteria established through courts	1
Not within reasonable staff resources	1
Collating greater volume of information	1
CARP system	1
Own footway maintenance ranking system	1
New Roads and Streetworks Act criteria	1

F. DESIGN AND CONSTRUCTION

F.1 (i) Widths, crossfalls and gradients being adopted for footways.

Width (m)	No. of responses	Gradient	No. of responses	Crossfall	No. of responses
1.0	1	1 in 12 max	1	1 in 20 -40	1
1.2	1			1 in 24	1
1.5	1			1 in 30	2
1.8	10			1 in 33 - 40	3
2.0	2			1 in 36	2
2.4	1			1 in 40	6
3.0	1			2.7%	1

F.1 (ii) Widths, crossfalls and gradients being adopted for vehicular crossings.

Crossfall

Crossfall	No. of responses
1 in 10	1
1 in 13 - 40	1
1 in 24	1
1 in 36	1
1 in 40	1

F.1 (iii) Availability of standard detail drawing or design guide.

Is such a guide available?	No. of responses
Yes	22
No	1

F.2 **(i) Adopted kerb type and upstand.**

Kerb Type	Dimensions (mm)	Upstand (mm)	No. of responses
Bullnosed	150 x 125	20	1
		-	2
45° splayed	-	-	-
Half batter	305 x 150	100	1
		125	1
	255 x 125	100	1
		(100 - 125)	1
		110	3
		125	12
		130	1
	150 x 125	-	4
Half batter	-	-	1
Granite	-	-	2
Figure 7's	-	120	1
Other	125 x 225	125	2

F.2 **(ii) Views on increasing upstand height to 150mm in light of the provision of increased pedestrian crossing facilities.**

Views	No. of responses
Support	4
Against - additional footway costs	2
Insufficient kerb support/stability	3
Oppose	10
Problem with tapered kerbs	1
Courts will object	1
Difficult for elderly	1
Use around gullies on flat	1

F.3 **(i) Methods of weed control.**

Methods used	No. of responses
Done by Cleansing Dept.	2
Mechanical sweeper fitted with spray bar	1
Twice yearly application	3
Weed killer	15
Annual application	7
Spray when necessary	1
Annual spray to kerbs, bi-annual to paved areas	1
Under review	1

F.3 **(ii) Effectiveness of methods.**

Effectiveness	No. of responses
Variable	3
Banning simazine and atrazine will cause problems	1
Problems with lightly trafficked surfaces	1
OK if applied correctly	1
Only effective on growing weeds	1
Not very effective	6
Under funded	1
Environmentally friendly materials increasingly ineffective	1
Relatively effective/effective	3

F.4 **Permissible depths of construction for vehicular crossings.**

Material	Depth of construction (mm)	No. of responses
Sub-base	115	1
	150	9
	175	2
	200	3
	225	1
Basecourse	35	1
	40	2
	45	1
	50	5
	60	7
	100	1
Wearing course	15	4
	20	10
	25	1
	40	1
Concrete	200	1
	225	1
	250	1
Blocks	275	1
Flexible	205	1
	220	2
	230	7
	240	1
	250	1
	255	1
	265	1
	275	1
	300	1
	as footway	1

G. METHODS OF MANAGEMENT

G.1 1991/92 structural highway maintenance spending.

Spending (£million)	No. of responses
0 - 1	3
1 - 2	4
2 - 3	1
3 - 4	3
4 - 5	2
5 - 6	2
6 - 7	1
8 - 9	1
9 - 10	3
13 - 14	1
14 - 15	2
16 - 17	1
24 - 25	1
25 - 26	1
38	1

G.2 (i) Percentage of structural maintenance budget spent on footway maintenance.

Percentage	No. of responses
0 - 10	-
11 - 20	6
21 - 30	6
31 - 40	6
41 - 50	3
51 - 60	1
61 - 70	2
71 - 80	2

(ii) Change in this percentage.

Change in this percentage	No. of responses
Increasing	9
Decreasing	1
Remaining more or less constant	14

(iii) How is budget derived?

Budget is:	No. of responses
Needs led	15
Historically based	3

G.3 **(i) Aims of footway management.**

What are the aims?	No. of responses
Keeping footways safe at minimum cost	8
Reference to LAA code	4
Maintain structural integrity /infrastructure /asset value at minimum cost	3
Provide adequate level of service for pedestrian movement	1
Reduce level of injuries	1
Respond as quickly as possible to complaints	1

(ii) Statement of maintenance policy.

Do you have such a statement?	Description of statement	No. of responses
Yes	Maintain safe and efficient movement and improve environment in shopping areas	1
	Preserve long term structural identity, enhance road safety, visual amenity and implement cost effective programmes	1
	Inspection procedures to reduce accidents and manual production of overall requirements	1
	Maintain footway in safe condition	1
	To be produced shortly	1
	Others	6
LAA code	-	2
In preparation	-	3
No	-	6

G.4 Footway expenditure split between the following:

(i) Planned major maintenance works

(ii) Planned preventative maintenance works

(iii) Non-programmed work

Ratio (i) : (ii) : (iii)

(i)	(ii)	(iii)	No. of responses
25	12	53	1
37	22	41	1
40	0	60	1
40	30	30	1
40	(ii)+(iii) 60		1
41	(ii)+(iii) 59		1
50	5	45	1
52	17	31	1
53	0	47	1
56	0	44	1
56	7	37	1
60	10	30	2
61	2	37	1
67	26	7	1
70	15	15	1
70	(ii)+(iii) 30		1
75	7	18	1
75	10	15	1
80	0	20	1
(i)+(ii)80		20	1
88	0	12	1
Cannot split expenditure			3

G.5 (a) frequencies of inspection

Frequency of inspection	No. of responses
LAA code	11
Annually	6
Urban 3 months, rural 6 months	1
Monthly	1
3 yearly	1
6 monthly maximum	1
Heavily used 4 months, classified 6 months, others 12 months	1
6 monthly but major shopping areas weekly or monthly	1
2 and 6 months	1
Classified 12 months, others 18 months	1
City centre monthly, designated areas 6 months, others 12 months	1
Town centre 6 months, others 12 months	1
No formal system	1

(b) intervention levels

Intervention levels	No. of responses
LAA code	12
20mm trip, cracked flag in city centre	1
20mm	1
19mm footways, 10mm city centre	1
25mm	1
Variable	1

G.6 Systems to prioritise footway works etc.

System description	No. of responses
Proforma	1
CHART	3
MARCH	11
CARP	4
Subjectively and politically	1
Divisions identify	1
LAA code	1
Visual inspection	1
Annual inspection and computer inventory	1
Inspectors and senior officers	1
Own rating formula	1
Historic needs	1
Highway inspectors	1
Others	2

G.7 (a) frequencies of inspection

Frequency of inspection	No. of responses
LAA code	11
Annually	6
Urban 3 months, rural 6 months	1
Monthly	1
3 yearly	1
6 monthly maximum	1
Heavily used 4 months, classified 6 months, others 12 months	1
6 monthly but major shopping areas weekly or monthly	1
2 and 6 months	1
Classified 12 months, others 18 months	1
City centre monthly, designated areas 6 months, others 12 months	1
Town centre 6 months, others 12 months	1
No formal system	1

(b) intervention levels

Intervention levels	No. of responses
LAA code	12
20mm trip, cracked flag in city centre	1
20mm	1
19mm footways, 10mm city centre	1
25mm	1
Variable	1

(c) response times

Response time	No. of responses
LAA code	9
>20mm 14 days, >30mm 7 days	1
>20mm 4 or 8 weeks, >50mm 3 days	1
Serious defects 24 hours, remainder 1 month	1
2 weeks	1
Minor repair immediately following inspection	1
Potentially dangerous within 1 hour	1
None	1

G.8 Recording systems.

Do you have such a system?	Describe System	No. of responses	Information storage	No. of responses
Yes	Hand-held data capture	5	Paper	4
	Paper system	16	Disc	3
	Both	3	Database	2
Being developed	-	1	Computer	2

G.9 Setting of maintenance standards.

Are standards set?	No. of responses
Yes	12
LAA code	8
In TPP	1
Being developed	2
No	4

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MORE INFORMATION FROM TRL

TRL has published the following other reports on this area of research:

PR95 Footway Maintenance Part 1: A review of profile monitoring techniques. Spong C C (1994). Price £10

PR96 Footway Maintenance Part 2: An assessment of profile monitoring equipment. Spong C C and Cooper D R C (1994). Price £10

PR97 Footway Maintenance Part 3: Footway profilometer end product/performance specification. Spong C C and Cooper D R C (1994). Price £10

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