VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE

SECTION 2 PAVEMENT DESIGN AND CONSTRUCTION

PART 5

HD 39/01

FOOTWAY DESIGN

SUMMARY

This part sets out the requirements and advice for new footway construction. It covers footways constructed from common materials that are subject to a range of pedestrian traffic and some overrun by vehicular traffic.

INSTRUCTIONS FOR USE

This is a new document to be incorporated into the Manual.

1. Insert HD 39/01 into Volume 7, Section 2, Part 5.

2. Archive this sheet as appropriate.

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

THE HIGHWAYS AGENCY

SCOTTISH EXECUTIVE DEVELOPMENT DEPARTMENT

THE NATIONAL ASSEMBLY FOR WALES
CYNULLIAD CENEDLAETHOL CYMRU

THE DEPARTMENT FOR REGIONAL DEVELOPMENT*

Footway Design

* A Government Department in Northern Ireland

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Contents

1. INTRODUCTION

General

1.1 This part provides guidance on new footway construction. It covers footways constructed from common materials and subject to a range of pedestrian traffic and some overrun by vehicular traffic. The design of cycleways is subject to further research and is not covered. Neither is the design of pedestrianised areas since the number of delivery vehicles usually means that a road pavement design will be required.

1.2 Guidance is provided on the construction of footways surfaced with bituminous material, concrete or clay pavers, precast concrete flags and in-situ concrete. Designs for paver and flag footways, in the situation where there is overrun by heavy vehicles, remain to be validated. Recommendations on the maintenance of existing footways, is given in HD 40 (DMRB 7.4.3).

Implementation

1.3 This Part shall be used forthwith on all schemes for the construction, improvement and maintenance of trunk roads currently being prepared, provided that, in the opinion of the Overseeing Organisation this would not result in significant additional expense or delay. Design organisations should confirm its application to particular schemes with the Overseeing Organisation.

Mutual Recognition

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

2. DESIGN CONSIDERATIONS

Introduction

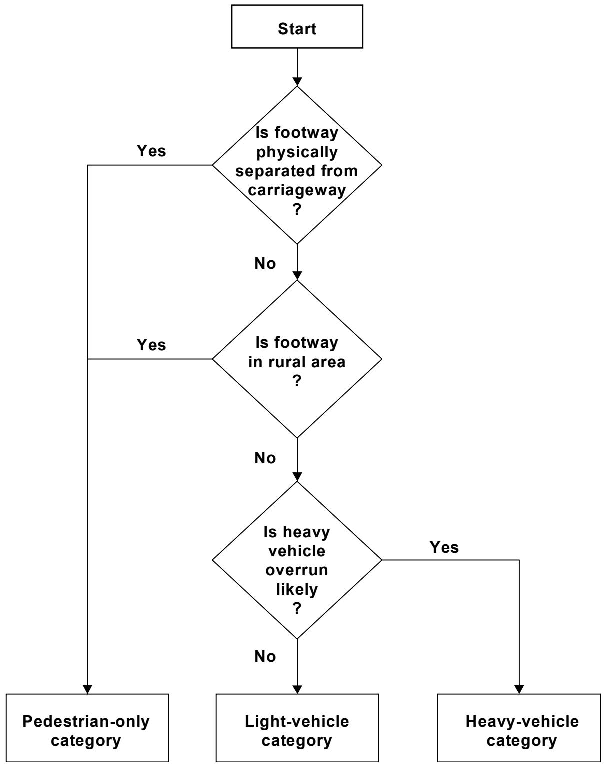
2.1 Maintaining Agents and Local Authorities spend a significant amount of their highway maintenance budgets on footways in order that all pedestrians, including those with mobility difficulties, can travel on the footway in comfort. The footway surface deteriorates for a variety of reasons and it is important that the initial construction is such that subsequent deterioration is minimised. Although it is expected that the upper layers will need attention because of general wear, it is recommended that the foundations of footways should be sufficiently robust to give good performance over a design life of 40 years.

2.2 Research has been carried out at the Transport Research Laboratory (TRL) to identify the causes of failure in footways and thus to recommend suitable designs to improve the surface condition of footways over their design life. Vehicle overrun and works by Statutory Undertakers have been identified as the most common causes of failure in footways. It is hoped that adherence to the HAUC Code of Practice Specification (DoT et al, 1992), or the NIRAUC Specification for the Reinstatement of Openings in Roads (1995) in Northern Ireland, will ensure improvement in reinstatements after utility works and consequently in the ensuing condition of the footway surface. Growth of vegetation, natural ageing of bituminous material, and poor design and construction have also been identified as significant causes of deterioration.

Selection of Footway Category

2.3 To choose the appropriate footway design it is necessary to consider the pedestrian and vehicular traffic which the footway may have to support and the characteristics of the ground on which the footway is to be constructed. Designs are given for three construction categories, the appropriate category being chosen according to the risk and type of vehicle overrun and on the amount of pedestrian usage.

The category required is selected by following the flowchart in Figure 2.1.



Pedestrian-only :	Footways designed for pedestrian use only.
Light-vehicle :	Footways which will support overrun by light vehicles
Heavy-vehicle :	Footways which will support overrun by heavy vehicles.

Figure 2.1 : Flowchart for Selection of Footway Category

Notes on Figure 2.1

1. The footway is considered to be physically separated from the carriageway if there is a verge of width 3m or more, closely spaced trees or other physical obstructions such that vehicular traffic cannot mount the footway.

2. Any footway in a residential area is likely to be used for parking private cars. However, if the footway is in a rural area it may be sensible to adopt the pedestrian-only design, even if vehicle overrun is not physically prevented. If there is little pedestrian traffic the risk of any damage by overrun causing inconvenience to pedestrians is small.

3. There are many situations where light vehicle overrun is common, but overrun by heavy vehicles would not be expected to occur more than very occasionally. This may apply to domestic crossings (access to private driveways); situations where cars may park between obstructions that would prevent heavy vehicles parking; and footways adjacent to roads on housing estates. Some heavy vehicle overrun is to be expected when footways are adjacent to roads in areas where deliveries take place, such as outside local shops. Obstructions, such as broken down vehicles, will cause traffic to overrun the footway occasionally.

4. 'Pedestrian only' footways are not designed to support any type of vehicle use, not even small cleaning and maintenance vehicles, except those that are pedestrian controlled.

Site Investigation

2.4 To perform satisfactorily, a footway must be constructed on an adequate foundation. A soft subgrade provides insufficient support for compaction of the layers above, which may subsequently deteriorate rapidly. For road pavement construction the subgrade is conventionally assessed in terms of its California Bearing Ratio (CBR) and as footways are associated with road pavements it is convenient to use the same measure.

2.5 Methods for measuring CBR are described in HD 25 (DMRB 7.2.2.4). If, because of site investigations prior to constructing structures, the Modulus of Subgrade Reaction (k) of the soil is known, this can be related to the CBR by the relationship given in HD 25 (DMRB 7.2.2).

2.6 Tests should not be carried out on the soil near the surface as the moisture content will not be representative of the equilibrium condition at depth. It is very important to remember that Design CBRs relate to equilibrium conditions. A prolonged dry spell may distort the results and lead to failure in wetter conditions. If a cone penetrometer is used to assess CBR, care must be taken in case services are present; the use of a Cable Avoidance Tool (CAT) is recommended.

2.7 The CBR chosen for design purposes should be the minimum measured value, not the average, otherwise local failure will occur at soft spots. Alternatively, soft spots can be removed and replaced with better material to improve the subgrade CBR value. If it is not possible to estimate the CBR because the condition of the subgrade is extremely variable then a default of 2 per cent should be assumed, unless the material is granular in which case the CBR can be assumed to be over 5 per cent.

2.8 For a footway subject to vehicle loading the estimate of CBR should normally relate to the moisture content which is expected to be present in the subgrade under the completed footway, when any change in the water table due to construction and the installation of drainage has taken place. However, if the in situ CBR at the time of measurement is less than the expected equilibrium CBR, then the in situ value should be used for design, otherwise failure may occur before equilibrium is reached.

2.9 Tables 2.1 and 2.2 provide guidance on estimating Design CBRs if testing is not possible. They are more conservative than the information presented for road pavements in HD 25 (DMRB 7.2.2.2), and should only be used in conjunction with the designs presented in this Part.

Soil Type	Plasticity Index	Design CBR%
Plastic Clay	50 or greater	2+
Silty Clay	40	2
Silty Clay	30	3
Sandy Clay	20	3
Sandy Clay	10	2+
Silt	-	Less than 2
Sand (poorly graded)	-	7*
Sand (well graded)	-	10*
Sandy Gravel (well graded)	-	15*

Notes: + CBR may be less than 2 if construction conditions are poor.

* Indicates estimated values assuming some probability of the material saturating in service.

Table 2.1 Equilibrium CBR Values

Soil Condition	CBR
Very soft, exudes between fingers when squeezed	Less than 1%
Can be moulded by light finger pressure	Between 1 and 2%
Can be moulded by strong finger pressure	Between 2 and 3%
Can be indented by a thumbnail but not by a thumb	More than 6%

Table 2.2 Rough Guide to CBR

Geometry

2.10 When assigning geometric parameters to footways the comfort of the user is taken into account, together with the necessity for providing adequate surface drainage. Steep gradients or crossfalls make it difficult for elderly or encumbered pedestrians to walk on the footway, while insufficient gradients would not facilitate the removal of surface water. Where possible the footway width should be sufficient to allow two wheelchairs or double buggies to pass. The basic geometrical parameters are set out in Table 2.3.

Parameter	Recommended Limits	Extreme Limits
Longitudinal gradient (normally the same as adjacent highway)	1.25% to 5%	8% maximum*
Width	2m minimum	1.3m minimum
Crossfall	2% to 3.3%	1.5% minimum to 7% maximum at crossings

Note: *In some cases it may be necessary to construct a footway with a gradient of more than 8 per cent. Provision of a handrail is recommended if site constraints necessitate a gradient steeper than 10 per cent.

Table 2.3 Geometric Parameters for Footways

2.11 Crossfall should be limited to that absolutely necessary to dispose of surface water. Crossfalls steeper than about 3 per cent are uncomfortable to walk on and if the slope runs towards a road it can be dangerous, as wheeled users will tend to edge down the crossfall.

2.12 The direction of the crossfall should take surface water away from buildings. However, if backfall towards buildings is unavoidable then covered drainage channels can be used to remove the surface water.

Drainage

2.13 The strength of the construction and of the subgrade can vary considerably with moisture content, so it is extremely important to keep the structure well drained during its service life. Issues of drainage relate to ensuring adequate longitudinal falls, grips/gullies and level tolerances to prevent surface water ponding and to aid its disposal. The drainage system should be designed to last the life of the footway and it should be easy to maintain. Drainage should be kept away from the centre of the footway because of the likelihood of works by Statutory Undertakers. Any potential problems which may be caused by tree and hedge roots should be considered.

2.14 Generally footway drainage will be the same as that of the adjacent highway, which should ensure a low water table and efficient disposal of surface water. Where a footway is separated from the highway the main consideration should be to ensure that surface water drains away from the footway into the highway. If a separate drainage system is required it should be simple and robust; it should keep the water table below formation level and deal satisfactorily with storm water. Regular maintenance of the drainage system will be necessary for long-term performance. Drainage is especially important if there is any risk of vehicle overrun, as a sub-base can lose a considerable proportion of its load spreading properties if it becomes waterlogged.

Statutory Undertakers

2.15 Where possible, footways should be designed so that services can run in the verge rather than under the footway. If this is not possible the provision of service ducts minimises any disruption during maintenance work. On new footways all Statutory Undertakers' equipment must be placed before the footway is formed. (Recommendations on positioning new services are contained in NJUG Publication Number 7, 1997). Any trenches excavated before construction of the footway should be backfilled with suitable material and fully compacted. Compaction of the backfill to any trenches should be carried out according to Appendix A8 in the HAUC Code of Practice Specification (DoT et al, 1992), or the NIRAUC Specification for the Reinstatement of Openings in Roads (1995) for

Northern Ireland, to ensure that the reinstatement will have a bearing capacity at least as good as the natural subgrade.

Environmental Considerations

2.16 The position of the footway and the choice of surfacing will be affected by environmental factors. The footway should complement the surrounding environment and natural features should be disturbed as little as possible. The roots of large trees can cause problems and ideally footways should not be positioned close to such trees. If footways must be built near to existing trees then material around the existing roots should be excavated carefully by hand, any sub-base or other granular material should be placed by hand and non-toxic sand should be placed around the roots. If necessary the vertical alignment of the footway can be lifted to facilitate this.

2.17 In a new development, trees should be carefully chosen to have deep rather than spreading roots and sufficient space must be provided for root growth. Planting verges with low shrubs discourages parking and removes the need for grass cutting, while maintaining sight distances. For ease of maintenance trees can also be underplanted with such shrubs.

2.18 The footway surface should be even and have adequate slip resistance and abrasion resistance. The type of surfacing chosen will depend on the required appearance, the usage of the footway, the available budget and the loading to which the footway is subjected. The recommended and most commonly used types of surfacing are bituminous materials (bitumen macadam or hot rolled asphalt), concrete or clay pavers and precast concrete (PCC) flags. It is not recommended that in situ concrete is used due to the difficulties caused when works by Statutory Undertakers are carried out, although concrete may be used locally for corner reinforcement against overrun and for vehicle crossovers. Natural stone flags, cobbles and setts are not commonly used for new footways as they tend to be both expensive and difficult to lay, though they are used in conservation areas.

2.19 If the pedestrian usage is very high, mastic asphalt can provide a very tough surface and it also provides a useful thin waterproof surface over cellars. In some areas, tactile surfacing may be required to assist those pedestrians who have impaired sight. (Refer to DETR publication "Guidance on the use of Tactile Paving Surfaces", also available on the internet: www.mobility_unit.detr.gov.uk/guide/ tactile/index.htm. In Northern Ireland refer to "Roads Service's Policy and Procedures Guide, RSPPG_E010"). Pavers, even when well laid, may not provide ride quality as good as bituminous or flag surfaces, which is a disadvantage for users of small wheeled buggies and the like.

2.20 A series of worked examples are provided in Annex E of this Part to demonstrate the design methods and the use of the Tables.

3. STRUCTURAL DESIGN

Introduction

3.1 For most soils, other than silt, the CBR of the subgrade at the time of construction will be at least 2 per cent, which should provide an adequate surface for compaction of the sub-base. If the CBR of the subgrade is lower than this, the soil can be stabilised, usually with lime (which should achieve a CBR of at least 5%), or some soil can be removed and replaced with extra granular sub-base/capping material.

3.2 Alternatively, if construction is being carried out in poor conditions, on a clay soil which is expected to have an equilibrium CBR of at least 2 per cent, there may be a case for using a geosynthetic separating layer as a construction expedient. The geosynthetic does not improve the CBR, but prevents soft ground contaminating the sub-base, which would weaken the structure and lead to inadequate support for compaction of the upper layers. Construction layers above the sub-base would consequently not be properly compacted and would deteriorate faster than would otherwise be the case, with subsequent increase in maintenance costs. The subgrade should be levelled and compacted before placing the geosynthetic or the sub-base.

3.3 If the sub-base is required to support construction traffic, then the sub-base thickness will need to be designed accordingly, even if the footway is a pedestrian-only design.

3.4 For prevention of frost damage all material within 450mm of the surface should be non frost-susceptible, unless the mean annual frost index is less than 50, in which case the requirement can be reduced to 350mm. Advice on the frost index for any particular area can be obtained from the Meteorological Advisory Services. The frost index is defined as the product of the number of days of continuous freezing and the average amount of frost, in degrees Celsius, on those days. If the subgrade is frost susceptible then it should be protected by a blanket of suitable non-frost susceptible materials.

3.5 Soils which are most likely to be frost susceptible are low plasticity clays, silts, and clayey and silty sands and gravels. Medium and high plasticity clays are normally insufficiently permeable to be susceptible to frost heave, and clean sands and gravels cannot generate sufficient suction to draw water to the ice front. Well drained soils where the water table is well below the construction are less likely to be damaged by frost in any situation, because footways are usually alongside road pavements and the road drainage would tend to ensure a low water table. It is unlikely to be cost effective to build the footway deep enough to totally prevent frost damage. Modular footways are less susceptible to frost damage as they can move without cracking.

Pedestrian-only Design

3.6 Construction thicknesses are as shown in Table 3.1, and construction materials are discussed further in Chapter 5 of this Part. The sub-base is a Type 1, see Specification Series 800 (MCHW 1) or equivalent material with a minimum compacted thickness of 100mm to ensure a smooth and regular laying surface for the upper footway layers. The wearing course is usually bituminous, concrete or clay pavers or PCC flags. If pavers are used the sub-base surface must be sufficiently dense to prevent bedding sand leaking down into it.

3.7 Using a single 60mm thick combined basecourse and wearing course avoids the problems associated with the compaction of very thin layers. The material cools down more slowly, allowing more time for compaction. However, it can be more difficult to achieve a good ride quality when a separate regulating layer is omitted. More care needs to be taken with the surface finish of the sub-base if bituminous material is to be placed in a single layer.

Layer \ Surface Options	Bituminous	Pavers		Flags
Surfacing[2]	20mm wearing course 40mm basecourse[1]	≥50mm clay pavers	≥60mm concrete blocks	≥50mm
		30mm bedding sand (compacted)		25mm bedding sand (compacted) or mortar
Sub-base[2]	100mm			
Subgrade[3]	-			

Table 3.1 Pedestrian-only Footways

Layer \ Surface Options	Bituminous	Pavers			Flags			Concrete
Surfacing[2]	20mm wearing course 40mm basecourse[1]	≥50mm clay pavers	≥60mm concrete blocks		300mm x 300mm x 60mm or 400mm x 400mm x 65mm or 450mm x 450mm x 70mm			150mm unreinforced, Grade C30P
		30mm bedding sand (compacted)			25mm bedding sand (compacted) or mortar			
Sub-base[2]	150mm	250mm	200mm	150mm	250mm	200mm	150mm	75mm
Subgrade[3]	-	CBR ≤2%	2% ≤ CBR ≤5%	CBR >5%	CBR ≤2%	2% ≤ CBR ≤5%	CBR >5%	-

Table 3.2 Light-vehicle Footways

Notes for Tables 3.1 and 3.2:

1. 60mm combined wearing/basecourse is an alternative, but may require a slurry surfacing if a close textured surface cannot be achieved.
2. Refer to Chapter 5 for material options.
3. It may be necessary to stabilise subgrade or replace with granular capping, if CBR <2%.

3.8 Slurry surfacing can be used to provide a fine textured surface if it is considered that the bituminous material used in a single 60mm layer would give a surface that is too open textured. However, this thin surfacing has a short life span and will probably need replacing every 4 years.

Light-vehicle Design

3.9 This design is used for cross-overs to private driveways and wherever light vehicle overrun is likely. Construction thicknesses are shown in Table 3.2. The designs for segmental footways are thicker than the equivalent designs for bituminous footways since experimental work has shown that segmental constructions do not exhibit equivalent load spreading ability to bituminous constructions. 50mm concrete pavers are now available and there is no reason to assume that their performance will be inferior to 50mm clay pavers. However, 50mm concrete pavers are not included in current British Standards and so cannot be recommended at present.

3.10 In situ concrete can be used for vehicle crossovers. Kent County Council (1988) recommend using an unreinforced concrete, class C30P, laid 150mm thick over 75mm of sub-base, as illustrated in Table 3.2.

3.11 If there is a possibility of very occasional heavy vehicle overrun, such as might occur two or three times a year with occasional delivery vehicles to private houses, and if the footway is being constructed on a weak subgrade, it is recommended that the constructions are strengthened to those illustrated in Table 3.3. Under bituminous surfacing, if the subgrade CBR is less than 2 per cent, the sub-base thickness should be increased to 225mm. If the wearing course is flags or pavers, a 70mm Dense Bitumen Macadam (DBM) or Cement Bound Material (CBM) layer (CBM1 or stronger) should be incorporated between the sub-base and the bedding sand where the subgrade CBR is 5 per cent or less. Where the subgrade CBR is above 5 per cent a sub-base thickness of 200mm should be sufficient to permit very occasional heavy vehicle overrun. No strengthening is necessary if the wearing course is of concrete construction.

Heavy-vehicle Design

3.12 If there is uncertainty about the type of overrun, or if the footway is adjacent to a busy road and overrun is not prevented by some physical means, then the footway should be designed to sustain heavy vehicle overrun. This does not include pedestrian areas that generally see a significant amount of delivery or maintenance vehicles. For such areas a road pavement design, as given in HD 26 (DMRB 7.2.3.2) is more appropriate.

3.13 For this category of footway the design traffic is assumed to be 50,000 standard axles. This allows for approximately one vehicle per working day over a design life of 40 years, equal to the design life of associated road pavements (assuming that one heavy vehicle is, on average, equivalent to one standard axle). The number of standard axles has been multiplied by 3 to take channelisation into account and some allowance has been made for dynamic loading due to the vehicle mounting the footway.

3.14 Recommended design thicknesses are given in Table 3.4, and are based on the performance of lightly trafficked roads (Road Note 29, Road Research Laboratory, 1970), with a minimum sub-base thickness of 150mm. This does not allow for the sub-base to be used as a platform for construction traffic. If the sub-base is to be trafficked the thickness must be increased to the values in HD 25 (DMRB 7.2.2.2). It is advisable that all footways subject to possible trafficking by heavy vehicles include a bound roadbase.

Layer \ Surface Options	Bituminous	Pavers or Flags		Concrete
Surfacing[2]	20mm wearing course 50mm basecourse[1]	As Table 3.2		As Table 3.2
Base[2]	-	70mm DBM (or stiffer) or CBM1 (or stronger)	-	
Sub-base[2]	225mm	150mm	200mm	
Subgrade[3]	CBR ≤2%	CBR ≤5%	CBR >5%	

Table 3.3 Light-vehicle Footways with Very Occasional Vehicle Overrun

Layer \ Surface Options	Bituminous	Pavers or Flags	
Surfacing[2]	25mm wearing course	As Table 3.2	
Base[2]	90mm DBM (or stiffer)	90mm DBM (or stiffer)	100mm CBM1 (or stronger)

Sub-base[2]	365mm	270mm	210mm	165mm	150mm
Subgrade[3]	CBR ≤2%	CBR ≤3%	CBR ≤4%	CBR ≤5%	CBR >5%

Note : Foundation requirements apply to all surface/base combinations

Table 3.4. Heavy-vehicle Footways

Notes for Tables 3.3 and 3.4 :

1. 70mm combined wearing/basecourse is an alternative, but may require a slurry surfacing if a close textured surface cannot be achieved.
2. Refer to Chapter 4 for material options.
3. It may be necessary to stabilise subgrade or replace with granular capping, if CBR <2%.

Edge Restraints

3.15 A requirement of all footway constructions is edge restraint, which is provided at the front by a kerb and at the back, unless the footway abuts a wall or building, by an edging (Figure 3.1). Good edge restraint is essential to prevent the footway spreading causing wide gaps in a segmental footway or longitudinal cracks in a bituminous footway which might allow water ingress. Wherever footways do not abut a kerb or existing boundary wall, precast concrete edging, laid on and backed with concrete to grade C7.5P, should be used. The sub-base should be extended beyond and beneath the edging. There should be a minimum of 100mm of sub-base under the concrete bed of the edge restraint. Common practice is to extend the carriageway formation and overlying sub-base under the kerb bed, which would normally give more than the minimum requirement of sub-base.

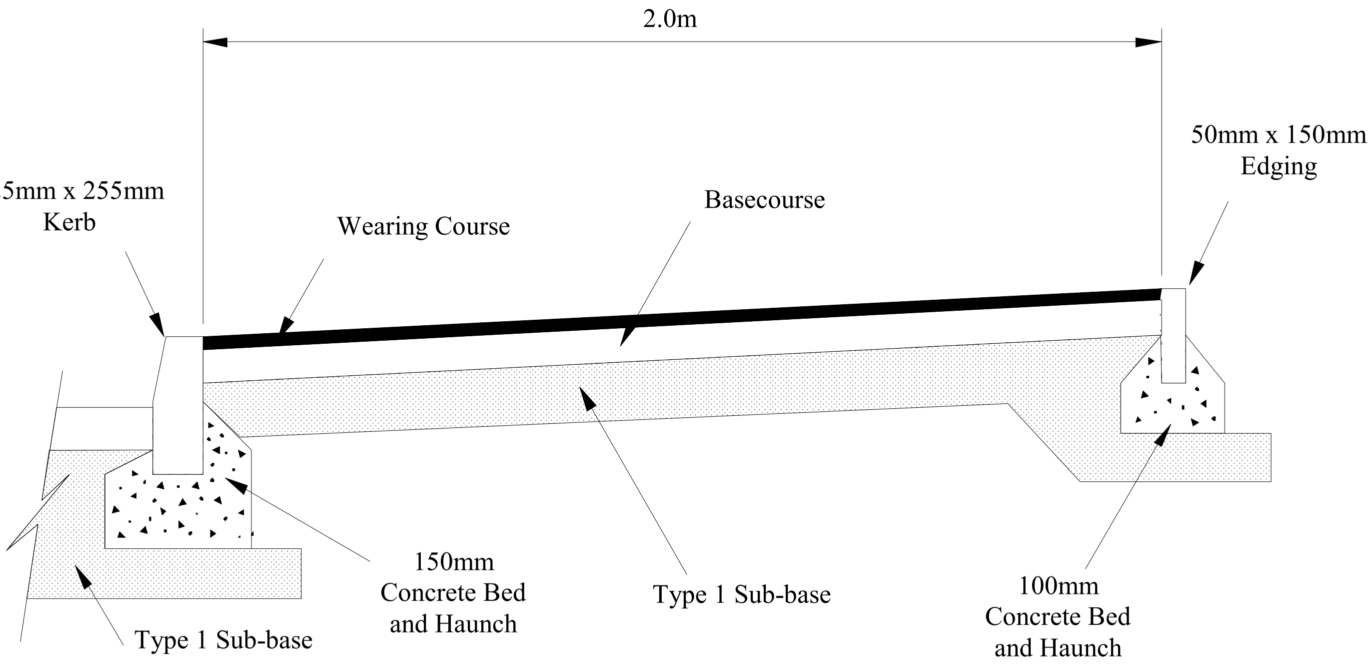


Figure 3.1 : Typical Pedestrian-only Footway Cross-section

4. MATERIALS

Introduction

4.1 Table 4.1 lists typical materials for use in footways, together with a reference for the material specification and for any sources of guidance. Background information on proprietary products such as slurry surfacing is contained within HD 37 (DMRB 7.5.2).

Materials	Specification	Guidance
Sub-base, Type 1 or CBM	MCHW Vol 1, Series 800 or 1000	MCHW Vol 2
50/14 hot rolled asphalt basecourse; 0/3F or 15/10F hot rolled asphalt wearing course	BS594: Part 1	BS594: Part 2
45/6F or 45/10F hot rolled asphalt wearing course	Annex A of this Part	
28mm dense bitumen macadam roadbase 20mm dense bitumen macadam basecourse; 14mm close graded bitumen macadam wearing course; 6mm dense bitumen macadam wearing course; 6mm medium graded bitumen macadam wearing course; 3mm fine graded bitumen macadam wearing course	BS 4987: Part 1	BS4987: Part 2
Laying course sand; Jointing sand	BS 7533: Part 3 (Note 1)	BS 7533: Parts 1–3
Clay pavers	BS 6677: Part 1	BS 6677: Part 3
Concrete blocks	BS 6717: Part 1	BS 6717: Part 3
Flags; Kerbs; Edging	BS 7263: Part 1	BS 7263: Part 2
Concrete, C30P	BS 5328: Parts 2,3 & 4	

Note: MCHW = Manual of Contract Documents for Highway Works
MCHW1 = Volume 1, Specification
MCHW2 = Volume 2, Notes for Guidance

Table 4.1 Materials

Sub-base

4.2 Type 1, see Specification Series 800 (MCHW 1) is the most commonly used sub-base material and generally originates from a primary aggregate source. For good compaction it should have a moisture content of +1% to -2% of optimum. If Type 1 is delivered too dry it can be prone to segregation. Although all materials should be protected from the weather when stored on site, providing Type 1 is not close to the fine limit of grading it will not retain water significantly above its optimum moisture content and any excess will rapidly drain from stockpiled material.

4.3 Type 1 was designed to be placed using large plant, in relatively thick layers and rolled using 8-10 tonne dead-weight rollers. Footways are constructed using small plant and are often laid in thin layers (100mm) for which the nominal size of Type 1 is too large. Alternative locally available materials may be suitable which fall into the category of secondary or recycled aggregates; for example:-

- Initial sweepings from 10mm and 14mm surface dressing
- Bituminous planings
- 20mm and 28mm nominal single sized aggregates
- Spent railway ballast screened to remove the 20mm down material (and thus any contaminants)
- China clay sand
- Crushed kerbstones
- Slate waste

The single sized nature of some of these sources may make them difficult to compact, so blending of aggregates may be beneficial. Bituminous planings exhibit considerable resistance to compaction due to friction of the bitumen coated aggregate. They must be compacted at optimum moisture content, to a maximum compacted layer thickness of 150mm.

4.4 If secondary aggregates are to be used, the requirements for durability set down in the Specification (MCHW1) for sub-bases should still apply. For example, materials used in the construction of the footway must be resistant to frost heave. Some materials, such as chalks, oolitic limestones, slate wastes, incinerator and furnace bottom ashes and colliery shales, both burnt and unburnt, may be subject to degradation due to freeze/thaw cycling. If it cannot be guaranteed that the sub-base will remain well drained throughout its design life then the material should be stabilised. Local experience can be a useful guide particularly where materials have a long history of satisfactory performance. Secondary aggregates may be suitable for use after stabilisation, for example by cement, foamed bitumen, or other binders. If it cannot be guaranteed that the sub-base will remain well drained throughout its design life then the material should be stabilised.

4.5 A permeable sub-base may be useful under modular surfacing, which is, to some extent, porous. It may therefore be better to provide the drainage at a lower level and have a more “free-draining” sub-base. This material is often referred to as Type 1X and a grading is available in TRL Report PA/SCR243, “Road Haunches: A guide to maintenance practice” (1994). Use of a permeable sub-base will only be possible where there are no services in the footway so that a welded felt type geosynthetic can be used to prevent flow of bedding sand into the voids.

Bituminous Materials

4.6 The decision on which bituminous materials to use will depend on appearance, durability, initial cost, maintenance requirements, total thickness, ease of laying and likelihood of disturbance by Statutory Undertakers. Where bituminous materials abut kerbs, manholes, small areas of tactile paving flags etc, the vertical faces of these should be cleaned and painted with a uniform coating of hot bitumen, before the bituminous material is laid. Advice can be found in BS 4987: Part 2.

4.7 Three wearing course materials that are suitable for footways are compared and contrasted in Table 4.2, assuming that all materials are fully compacted; the dense materials comply with the specification in Annex C of this Part, and 200 pen or harder bitumen is used. The good durability of the 45/6 HRA wearing course compared to the 6mm medium graded bitumen macadam, and its comparatively small extra cost, means that it is probable that the HRA will have the lowest cost over the life of the footway. However, a limestone aggregate is specified, so it may not meet skid resistance recommendations.

4.8 Permanent cold-lay surfacing materials (PCSMs) are currently being developed and this will allow hours rather than minutes for handling and compaction. Early results suggest that these materials are as durable as equivalent hot materials when laid on footways (TRL Report 134) but their long term performance remains to be established. At the moment, unless NJUG accreditation has been gained, their use should be restricted to the pedestrian-only category of footways.

4.9 The choice of basecourse may be limited because of the thickness specified in the design. Pedestrian-only footways require 40mm of basecourse, which is below the minimum thickness for basecourse complying with BS 4987. The solution is to either use a 14mm close-graded wearing course as a basecourse or a 50/14 hot rolled asphalt basecourse, the latter being more expensive but more durable. Alternatively, the basecourse and wearing course can be combined into a single layer, which could be a 45/10 hot rolled asphalt wearing course, as shown in Annex A of this Part.

4.10 The binder penetration should be specified as 100 pen or less where vehicle overrun occurs, otherwise 200 pen can be specified.

Material / Property	6mm medium graded bitumen macadam	6mm dense bitumen macadam	45/6 hot rolled asphalt
Appearance	open textured	close textured	smooth
Durability	poor to fair	fairly good	good
Workability	good	fair	good
Maintenance needs	highest	intermediate	lowest
Permeability	permeable	slightly permeable	effectively impermeable
Resistance to stiletto heels and horses	fairly poor	poor when new, otherwise good	fairly good

Table 4.2 Comparison of Bituminous Wearing Courses

4.11 The pavers or flags chosen will depend on the footway category and on aesthetic considerations. Large flags can be difficult to lay, requiring mechanical handling, and will be damaged by any vehicle overrun. Flags for footways other than strictly pedestrian only, should therefore be restricted to those of plan dimension 450 x 450 mm or less – types E, F or G to BS 7263: Part 1. Natural stone flags, where used, should conform to the above maximum plan dimensions if they are to support any vehicular traffic, but consideration should also be given to durability and abrasion resistance.

4.12 400 x 400 x 65mm flags are compatible with the standard 200 x 100 x 65mm rectangular concrete blocks so that the two types of surfacing can be combined to form attractive layouts. However, if these products are to be used together the joint spacings for the flags need to be relaxed to allow wider joints. Tactile flags are available in compatible sizes and are of the correct colour, and should be used at crossings.

4.13 It is possible to include clay pavers in schemes that also use flags and/or concrete blocks, but the tolerances on sizes of clay are different from and less onerous than the tolerances on concrete pavers and flags, and therefore laying problems may occur. It is possible to obtain clay pavers to the tighter tolerances of concrete, but they are likely to be more expensive.

4.14 Difficulties may be caused if advantage is taken of the larger variety of shapes, sizes and colours of concrete blocks available. Stocks of each type and colour would need to be kept for maintenance purposes. It is therefore suggested that blocks are specified as rectangular, with plan dimension 200 x 100mm. Installation should follow the current British Standard and further guidance is available from the appropriate trade association (Interpave for concrete blocks and Brick Development Association for clay pavers).

Bedding Sand

4.15 The bedding sand and jointing material should be in accordance with Annex B of this Part; Class II bedding sand being used for footways designed to support heavy-vehicle overrun, and Class III elsewhere. The moisture content of the bedding sand should be within +/-1% of optimum determined in accordance with BS 1377: Part 4: 1990, Method 3.3. The quality of the bedding sand is critical to long life. The sand must be free of deleterious salts or contaminants. Sand from quaternary geological series and sea dredged sands are preferred. Sands from crushed rock sources and triassic geological series in the north-west are not advised particularly for Heavy-vehicle Footways. Gradings should be checked by wet sieving.

4.16 Jointing material should not be of a type which could stain the surface, and should be supplied and installed kiln dry and free flowing. The need to guard against risk of failure due to removal of sand by suction sweepers during early life should be recognised. There are various proprietary sealing products available to prevent the loss of jointing sand, but they have yet to be proven satisfactory in the long term.

Compaction

4.17 The choice of compaction plant is limited by the small scale of the works, and obstructions such as street furniture, but the use of appropriate plant is essential, together with an established testing scheme when required. The subgrade must be levelled and compacted adequately if the sub-base, when placed and compacted, is to achieve the required density. The performance of both unbound and bound materials depends substantially on the degree of compaction achieved.

4.18 Compaction of asphalt materials can be carried out by a method specification (refer to Annex D of this Part), but it is important that the work is adequately supervised to ensure that the requirements are being achieved. However, as dense bitumen macadams are more difficult to compact it is recommended that they are compacted to satisfy an end-product specification, in terms of air voids (refer to Annex C of this Part).

4.19 The durability of dense bituminous materials of all types is heavily dependent on reducing the permeability of the material to a level which will restrict weather and oxygen attack to the top surface. The level of compaction is best characterised by air void content which is generally recommended to be in the region of 2-8%. Void contents less than 2% are not recommended for heavy-vehicle footways (Table 3.4), else deformation may occur under trafficking.

Skidding Resistance

4.20 The footway wearing course must not become slippery and difficult for pedestrians to walk on when wet. It is unlikely that this will be a problem with bituminous or concrete materials, but care should be taken when specifying clay pavers or natural stone. The skidding resistance of concrete products is always adequate for use in footways, as the BS 6717 requirement for acid soluble content precludes the use of limestone for both coarse and fine aggregates. Some clay pavers in areas of heavy pedestrian use can become slippery when wet. The resistance to polishing of clay pavers is expressed as a polished paver value (PPV). As a first approximation PPV is equivalent to polished stone value (PSV) for aggregates. A minimum polished paver value (PPV) of 45 should be specified for general use. Further guidance on skid resistance is available in CSS publication ENG1-96. “The assessment of slip resistance in paved areas for use by pedestrians and horse riders”.

Tolerances

4.21 The tolerances given in Table 4.3 are intended to apply generally and also take into account that a footway is usually hand laid. They are more stringent than those in Table 7/1, Clause 702, of the Specification (MCHW1). This is because the tolerances for road pavements would allow too great a reduction in layer thicknesses for thin footway construction layers. If kerbs and edging strips are properly laid it should be possible to achieve a high degree of compliance with design levels. Surface regularity is given in terms of maximum deviation under a 1m straightedge, as the 3m straightedge used in road pavement measurement is too large for footway use.

Testing

4.22 In order to reduce the need for testing incoming materials, all materials should be supplied under a quality assurance scheme, preferably a product certification type, which gives the most assurance of the product conforming to the required standards. No scheme absolves the purchaser from checking the quality of supply. If products are kitemarked, testing should only be necessary when the visual appearance differs from normal. The frequency of testing certified products would normally be between 10 per cent and 20 per cent of the frequency for uncertified ones. Where none of the above schemes apply then a much more frequent regime of testing will be required.

4.23 Testing should be carried out in accordance with Table NG 1/1, Notes for Guidance (MCHW2). Where possible the testing should be carried out by a laboratory which is NAMAS accredited for the particular test. Sampling is a very important part of any test and should be undertaken by a laboratory accredited for sampling. All sampling and testing should be carried out in accordance with the appropriate standards. The materials related tests most relevant to footway construction are given in Table 4.4.

4.24 The monitoring and testing of workmanship at all stages of construction is very important. Bituminous materials are more likely to fail early because of poor compaction than because the material was delivered out of specification, particularly on footways where it is more difficult to carry out complete compaction while the material is still hot. A guide to the type and frequency of testing for workmanship is given in Table 4.5.

4.25 As the quality of workmanship will depend on the operatives and their supervisor it is advisable that the chosen contractor has a QA scheme which spells out training for operatives. Each job should have a qualified supervisor and the checks that he will make should be listed.

Parameter	Tolerances
Horizontal alignment accuracy	Horizontal alignments shall be correct to within 25mm, except for kerbs, channels and edge strips which shall be correct to within ±13mm.
Formation level	After completion of any drainage and immediately before laying sub-base the subgrade surface shall be within + 10mm and –30mm of its design level.
Sub-base level	If the footway is surfaced in bituminous material the compacted sub-base surface shall be within +10mm and –20mm of its design level. If segmental surfacing is used the sub-base must be within ± 10mm of its design level.
Sub-base thickness	The thickness shall not be more than 10mm less than specified.
Bituminous basecourse	The compacted basecourse level shall be within ± 10mm of the design level.
Wearing course	The wearing course level shall be within + 5mm and –0mm of the adjacent kerb, edging strip or any ironwork.
Bituminous thickness	The total thickness of bituminous material shall not be more than 5mm less than specified.
Bedding sand	The compacted bedding sand level shall be within ± 5mm of the design level and not less than 25mm thick.
Kerbs and edging strips	The surface level shall be within ±6mm of the design level.
Joints between flags and pavers	Joints should be not less than 2mm and not more than 5mm wide. For pedestrian-only footways flags can be laid with wide (6-10mm) joints filled with compacted mortar.
Surface regularity	The maximum deviation of the footway surface under a 1m straightedge shall not exceed 3mm.

Table 4.3 Tolerances

Material	Test	Frequency of testing
Drainage		All drainage pipes will be checked for satisfactory operation.
Geosynthetics	Tensile load Permeability Pore size	1 per 400 square metres.
Type 1 sub-base	Grading Plasticity Index 10% fines value Soundness	1 per 400 tonnes 1 per 400 tonnes 1 per source 1 per source
Bituminous mixtures	Grading Binder content	1 per source 1 per source
Compacted bituminous material	Percentage refusal density	As required in BS 4987: Part 2
Precast concrete flags	Transverse strength Water absorption	Minimum of 3 per 1000 units of each product (BS 7263: Part 1) No frequency recommended
Concrete block paving	Compressive strength	16 per 5000 blocks (BS 6717: Part 1)
Clay pavers	Transverse breaking load Skid resistance	Minimum of 10 per 10000 pavers (BS 6677: Part 3) Minimum of 5 per 10000 pavers (BS 6677: Part 3)

Table 4.4 Materials Related Testing

Parameter	Test	Frequency
Foundation CBR	Visual, Mexe penetrometer for vehicle overrun	Visual over whole site, Mexe penetrometer on soft spots or every 50m.
Formation level	Levelling or dipping	Every 25 linear m and where doubt exists
Sub-base moisture content	Field identification according to HAUC Code of Practice Specification	Each delivery
Sub-base thickness	Dips before and after laying (trial holes in case of dispute only)	Every 25 linear m
Sub-base compaction	Density. Compare with trial area	Average of 3 per 500 linear m or part thereof
Bituminous materials	Temperature (°C)	On delivery and throughout laying
All compacted bituminous materials except medium graded macadam	Air voids or layer thickness (from cores or dips)	Average of 3 per 500 linear m or part thereof
Medium graded macadam	Layer thickness (from cores or dips)	Average of 3 per 500 linear m or part thereof
Ride quality	Rolling straightedge	Whole length
Surface regularity	1m straightedge and wedge	Every 25 linear m and where doubt exists

Table 4.5 Frequency of Testing for Workmanship

5. REFERENCES AND BIBLIOGRAPHY

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BS 6677: Part 1: Clay and calcium silicate pavers for flexible pavements: Part 1: Specification for pavers.

1990

BS 7263: Precast concrete flags, kerbs, channels, edgings and quadrants. Part 2: Code of practice for laying.

1992

BS 882: Specification for Aggregates from natural sources for concrete.

BS 594: Hot rolled asphalt for roads and other paved areas. Part 1: Specification for constituent materials and asphalt mixtures. Part 2: Specification for the transport, laying and compaction of rolled asphalt.

BS 7533: Guide for the structural design of pavements constructed with clay or concrete block pavers.

1993

BS 6717: Part 1: Precast concrete paving blocks: Part 1: Specification for paving blocks.

BS 4987: Coated macadams for roads and other paved areas: Part 1: Specification for constituent materials and for mixtures. Part 2: Specification for transport, laying and compaction.

1994

BS 7263: Precast concrete flags, kerbs, channels, edgings and quadrants. Part 1: Specification.

1997

BS 7533: Pavements constructed with clay, natural stone or concrete pavers. Part 3: Code of practice for laying precast concrete paving blocks and clay pavers for flexible pavements.

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"Precast Concrete Paving - a design handbook". Interpave, The Precast Concrete Paving and Kerb Association, Leicester, 1999.

6. ENQUIRIES

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

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ANNEX A SPECIFICATION FOR 45% TYPE F ASPHALT

Extract from the County Surveyors' Society Pavement Design Manual, ENG/6-94 (unpublished).

BS Sieve	Percentage by mass of total aggregate passing BS Test Sieve	
	45/6F	45/10F
14mm		100
10mm	100	90-100
6.3mm	85-100	45-80
2.36mm	45-57	45-57
600µm	34-57	34-57
212µm	8-35	8-35
75µm	4-8	4-8

Table A.1 - Type A : Grading for 45% Stone Asphalt

Notes:

Maximum % of aggregate passing 2.36mm sieve and retained on 600µm sieve is 11.0%.

Binder content percentage by mass is 6.6%.

The coarse aggregate shall be crushed rock with a polished stone value as described in the contract. For 45/6, which is for footway use only, the aggregate shall be limestone.

The binder shall be 200 pen bitumen and the maximum temperature at any time for this binder shall be 160°C.

ANNEX B SPECIFICATION OF BEDDING SAND AND JOINTING MATERIAL FOR SMALL ELEMENT PAVING

Sieve Size	Percentage Passing	
	Class II	Class III
5mm	90-100	90-100
2.36mm	75-100	75-100
600µm	35-60	35-70
300µm	8-35	8-35
150µm	0-10	0-10
75µm	0-1	0-3

Table B.1 : Grading for Bedding Sand

Sieve Size	Percentage Passing
2.36mm	100
1.18mm	95-100
600µm	55-100
300µm	15-50
150µm	0-15
75µm	0-3

Table B.2 : Grading for Jointing Material

ANNEX C COMPACTION SPECIFICATION

Material	Mean of 6 Cores		Mean of Pairs	
	Min	Max	Min	Max
Dense macadam wearing course	2%	6%	1%	8%
Dense macadam basecourse (BS4987 cl 6.5) and 14mm close graded wearing course used as a basecourse	2%	7%	1%	9%
All asphalt materials, ie roadbase, basecourse and wearing course	2%	6%	1%	8%

Table C.1 : Air Void Limits

C.1 The adequacy of compaction of bituminous materials will be judged against the air void levels given in Table C.1. The following procedure should be used.

C.2 Compliance should be judged from the determination of air voids for areas of 1000m² or from the area laid in one day where the area is less than this. Where a number of small areas are laid in a day the client should determine whether these are to be grouped into one site for testing purposes. Three 100mm nominal diameter core pairs should be taken from each area in a random manner.

C.3 The density corresponding to zero air voids should be determined using ASTM method D2041-91. One core from each set of six should be taken for the determination of the maximum density; where only one set is taken then the determination should be carried on 2 cores from the set.

C.4 When the material contains applied chippings the void content should be calculated from the whole layer including chippings.

C.5 The air void content should be calculated as $100(1-D_m/D_o)$ per cent, where D_m is the measured density and D_o is the ASTM D2041-91 density, and should be calculated for the whole layer including chippings.

C.6 The Contractor should inform the Engineer of the sources of the constituents of the mixes at the start of the contract and of any changes during the contract.

C.7 Where these requirements for the air voids are not met the Contractor should determine the full extent of the area of the defective material to the satisfaction of the Engineer. The full depth and width, minimum 15m long and the full width of the footway, of the defective material should be removed and replaced with fresh material laid and compacted to this Specification.

C.8 The nuclear density gauge (NDG) may be used to reduce the amount of coring required but in case of dispute the core density method should be used.

ANNEX D COMPACTION BY METHOD SPECIFICATION

		Granular			Bituminous		
		Compaction passes required for layers of compacted thickness up to:					
		100mm	150mm	200mm	50mm	75mm	100mm
Vibrotamper	50Kg minimum	6	12	u/s	6	9	12
Vibrating Roller	Over 600 - 1000Kg/m twin vibrating drum	6	12	u/s	6	9	12
	Over 600-1000 Kg/m single vibrating drum	12	u/s	u/s	12	u/s	u/s
	Over 1000-2000Kg/m twin vibrating drum	3	6	12	4	6	8
	Over 1000-2000Kg/m single vibrating drum	6	12	u/s	8	12	u/s
	Over 2000Kg/m twin vibrating drum	2	3	4	3	4	5
	Over 2000Kg/m single vibrating drum	3	5	7	6	8	10
Vibrating Plate	Over 1400-1800Kg/m²	5	9	u/s	8	12	u/s
	Over 1800Kg/m²	3	5	7	4	6	8

Table D.1 : Specified Passes for Various Compaction Plant

u/s - compaction plant is unsuitable for that material/layer thickness.

Vibrotampers are not the recommended plant for bituminous wearing courses.

ANNEX E WORKED EXAMPLES

EXAMPLE 1

A footway is to serve terraced dwellings on a new estate, linking them to a small garage court. Barriers prevent children running straight out into the garage court, which is surfaced in concrete pavers. From the ground investigation, prior to building the estate, the CBR is 2%. There are no services under the footway.

Stage 1: **Decide appropriate footway category** *Chapter 2, Figure 2.1*

Footway is physically separated from the carriageway. Footway is not a cycleway, therefore category is pedestrian-only.

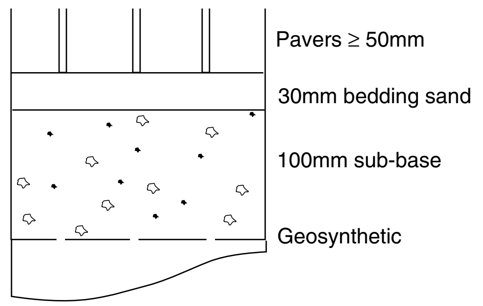
Stage 2: **Check design considerations** *Chapter 2, Table 2.3*

Width and gradients should be within the limits of Table 2.3. Crossfall should run away from houses. Adequate drainage should be provided. The plan shows that there are no services under the footway. The footway surfacing should enhance the environment; concrete pavers would be chosen to match the garage court.

Stage 3: **Structural design** *Chapter 3, Table 3.1*

There are no services in the footway so a geosynthetic can be used to separate the subgrade from the granular sub-base. Design CBR is 2 per cent.

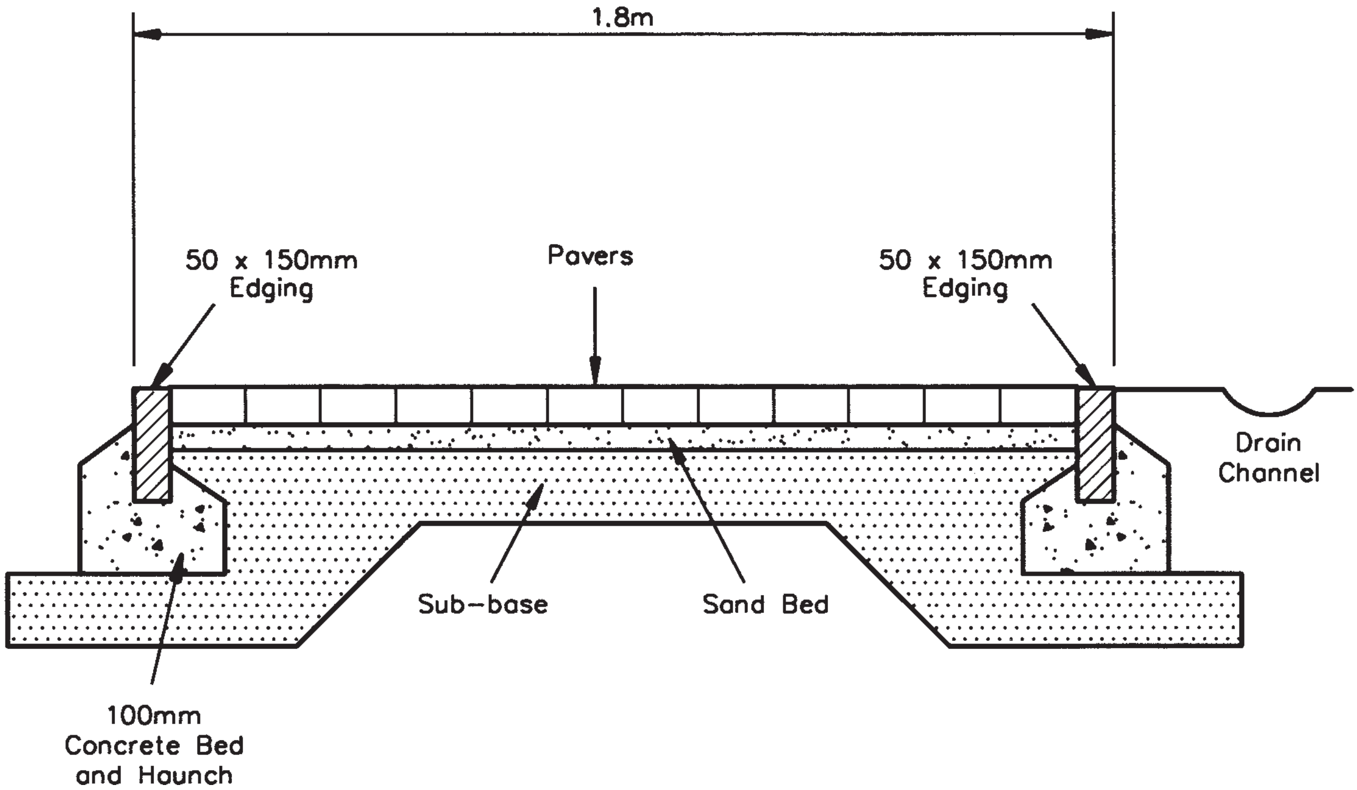
The structural design (pedestrian-only) is:



Note: Pavers can be chosen to contrast with the paved parking area to signify a change of use.

Stage 4: Construction ***Chapters 3 and 4***

As the footway is not adjacent to a road or wall, edge restraint should be provided on both sides of the footway. The cross section of the footway is as follows:



EXAMPLE 2

A new school has been built on the outskirts of a rural village. A footway is required to connect the school to the neighbouring village so that pupils can cycle or walk to school safely. The road running past the school is a rural lane, but there is ample parking and delivery space in the school grounds. At present the lane has a 3m wide grass verge bounded by a hedge. The soil along the verge is a soft clay. The length for which a footway is required is approximately 1 km.

Stage 1: Decide appropriate footway category ***Chapter 2, Figure 2.1***

Footway is not physically separated from the carriageway and may be considered to be lightly used. However, footway is also to be used as a cycleway, which may require the use of clearing and maintenance vehicles, so it would be wise to design for light-vehicle category.

Stage 2: Estimate subgrade CBR ***Chapter 2, Table 2.2***

Soil is very soft clay. A quick test shows that it "exudes from the fingers when squeezed". According to Table 2.2, this indicates a CBR of less than 1%.

Stage 3: Check design considerations ***Chapter 2, Table 2.3***

Width and gradients should be within the limits of Table 2.3. A minimum of 2m width is required which could usefully be increased to 2.5m to provide space for cyclists to overtake pedestrians. The gradient will be as for the road. The crossfall will be towards the road utilising existing drainage. The length and situation of the footway make a bituminous construction the best option. If there are services in the verge they may need to be moved or made deeper.

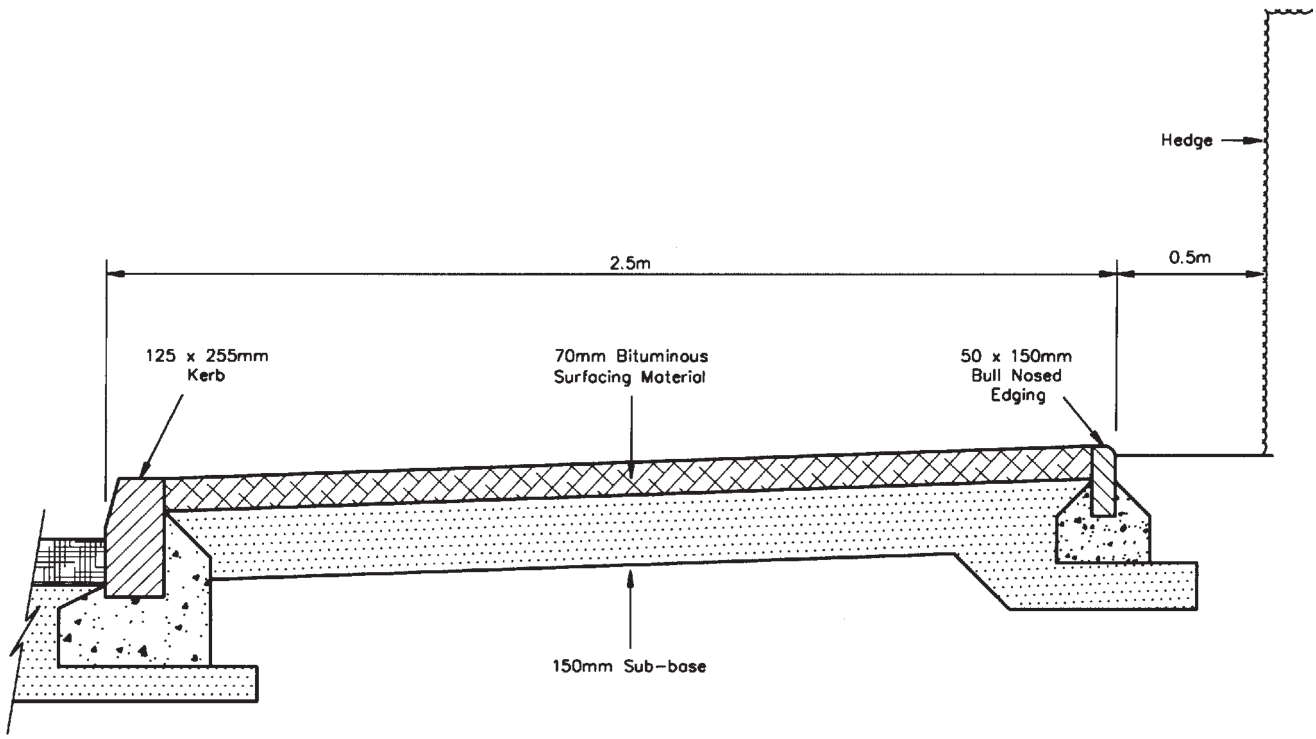
Stage 4: Structural design ***Chapter 3, Table 3.3***

CBR < 1%. Assume lime stabilisation is used to raise the design subgrade CBR to over 5 per cent.

Very occasional heavy vehicle overrun may occur, but the treated subgrade now has a CBR > 5% so the designs in Table 3.3 can be used. The structural design is 70mm of bituminous material on 150mm of sub-base.

Stage 5: **Construction** *Chapters 3 and 4*

The kerb provides the lateral restraint on one side of the footway, edging is required on the other side. The cross section of the footway is as follows:



EXAMPLE 3

A footway is to be built alongside an existing road, which now receives some pedestrian traffic due to construction of an out-of-town shopping area. There will be no verge between the footway and the carriageway, as the existing verge, on which the footway is to be constructed, is only 1.8m wide. There is a brick wall along the whole length of verge. It has been decided that concrete blocks will be used as the footway surfacing. The soil is sandy clay. Delivery vehicles may overrun the footway occasionally if, for example, the road is partly blocked by a broken down vehicle.

Stage 1: **Decide appropriate footway category** *Chapter 2, Figure 2.1*

Footway is not physically separated from the carriageway, and is not very lightly used. Heavy vehicle overrun is likely to occur. Therefore the footway category is heavy-vehicle.

Stage 2: **Estimate subgrade CBR** *Chapter 2, Table 2.1*

Soil is a sandy clay. From Table 2.1 the subgrade CBR is likely to be approximately 3 per cent. Testing is required to confirm this.

Stage 3: **Check design considerations** *Chapter 2, Table 2.3*

Width and gradients should be within the limits of Table 2.3. The gradient will be as for the road. The crossfall will run towards the road utilising existing drainage.

Stage 4: Structural design ***Chapter 3, Table 3.4***

The subgrade CBR = 3%, so no treatment is necessary.

The required sub-base thickness for heavy-vehicle design is 270mm. Concrete blocks should be at least 60mm thick and should be placed on 30mm compacted thickness of bedding sand. A roadbase of 90mm DBM or 100mm CBM1 or stronger, is required between the sub-base and the bedding sand.

Stage 5: Construction ***Chapters 3 and 4***

The brick wall provides lateral restraint on one side of the footway and the kerb provides lateral restraint.