Pavements constructed with clay, natural stone or concrete pavers —

Part 1: Guide for the structural design of heavy duty pavements constructed of clay pavers or precast concrete paving blocks

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee B/507, Paving units and kerbs, upon which the following bodies were represented:

Brick Development Association
British Cement Association
British Ceramic Research Ltd.
British Precast Concrete Federation Ltd.
Cementitious Slag Makers' Association
Country Surveyors' Society
Department of the Environment, Transport and the Regions (Highways Agency)
Institution of Civil Engineers
Institution of Highways and Transportation
Interlay, the Association of Block Paving Contractors
Interpave, the Concrete Block Paving Association
Landscape Institute
Society of Chemical Industry
Stone Federation

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Civil Engineering Test Equipment Manufacturers' Association
Institution of Structural Engineers
National Federation of Clay Industries Ltd.
National Paving and Kerb Association

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Contents

Foreword

This part of BS 7533 has been prepared by Technical Committee B/507. It supersedes BS 7533:1992, which is withdrawn.

BS 7533 will be published in the following parts:

— *Part 1: Guide for the structural design of heavy duty pavements constructed of clay pavers or precast concrete paving blocks;*

— *Part 2: Guide for the structural design of lightly trafficked pavements constructed of clay pavers or precast concrete paving blocks;*

— *Part 3: Code of practice for laying precast concrete paving blocks and clay pavers for flexible pavements;*

— *Part 4: Code of practice for the construction of pavements of precast concrete flags or natural stone slabs;*

— *Part 5*[1]*: Guide for the design of pavements (other structural aspects);*

— *Part 6: Code of practice for laying natural stone, precast concrete and clay kerb units;*

— *Part 7*[1]*: Code of practice for the construction of pavements of natural stone setts;*

— *Part 8*[1]*: Guide for the structural design of lightly trafficked pavements of precast concrete flags and natural stone slabs.*

— *Part 9*[1]*: Code of practice for laying clay pavers.*

Annexes A, B and C are informative.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 15 and a back cover.

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1 Scope

This British Standard provides guidance on the design of flexible pavements surfaced with clay or concrete block pavers manufactured in accordance with BS 6677-1 and BS 6717-1 respectively and laid in accordance with BS 7533-3. It applies to all pavements subjected to the usual road spectrum of axle loads up to 18 000 kg and trafficked by between 0.5 million standard axles (msa) and 12 msa, including both highway pavements and industrial pavements where the traffic is similar in character to highway vehicles. It specifically excludes heavy duty pavements with traffic exceeding 12 msa and other applications such as aircraft pavements and those in ports and specialized industrial areas.

NOTE 1 For design guidance for traffic levels of up to 0.5 msa, reference should be made to BS 7533-2.

NOTE 2 This design method can also be used for pavements constructed with stone blocks having the dimensions, tolerances and characteristics consistent with the relevant requirements for clay and/or concrete pavers.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 594-1, *Hot rolled asphalt for roads and other paved areas — Part 1: Specification for constituent materials and asphalt mixtures.*

BS 594-2, *Hot rolled asphalt for roads and other paved areas — Part 2: Specification for the transport, laying and compaction of rolled asphalt.*

BS 1377-4:1990, *Methods of test for soils for civil engineering purposes — Part 4: Compaction-related tests.*

BS 4987-1, *Coated macadam for roads and other paved areas — Part 1: Specification for constituent materials and for mixtures.*

BS 4987-2, *Coated macadam for roads and other paved areas — Part 2: Specification for transport, laying and compaction.*

BS 6677-1, *Clay and calcium silicate pavers for flexible pavements — Part 1: Specification for pavers.*

BS 6717-1, *Precast concrete paving blocks — Part 1: Specification for paving blocks.*

BS 7533-2, *Pavements constructed with clay, natural stone or concrete pavers — Part 2: Guide for structural design of lightly trafficked pavements constructed with clay or concrete block pavers.*

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

Department of Transport *Specification for Highway Works*, 1986 edition. Department of the Environment, Transport, and the Regions, London: The Stationery Office.

3 Terms and definitions

For the purposes of this part of BS 7533 the following terms and definitions apply.

3.1

paver

either a clay paver or a concrete block paver

3.2

laying course

layer of material on which pavers are bedded

3.3

subgrade

upper part of the soil, natural or constructed, that supports the loads transmitted by the overlying pavement

3.4

subgrade improvement layer

capping layer

layer of granular or treated material at the top of the subgrade to provide an improved foundation for the pavement

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3.5

sub-base

one or more layers of material placed immediately above the subgrade

3.6

roadbase

one or more layers of material placed above the sub-base that constitute the main structural elements of a pavement

NOTE The roadbase can be a bituminous material and/or cement bound material.

3.7

channelized traffic

traffic where the vehicle track width and the traffic lane width are virtually the same

NOTE Normal lane widths in a highway do not constitute channelized traffic.

3.8

dynamic loading

spectrum of loads normally occurring on highway pavements at vehicle speeds exceeding 30 mile/h (50 km/h)

3.9

standard axle

axle carrying a load of 8 200 kg

3.10

cumulative traffic

number of standard axles a pavement is designed to carry, measured in million standard axles (msa)

3.11

commercial vehicle

vehicle having an unladen weight exceeding 1.5 t

3.12

flexible pavement

pavement, constructed with pavers jointed with sand laid on a laying course, which is assumed to behave in a flexible manner

4 General design criteria

4.1 Basis of design

The design of new flexible pavements is based upon the method given in TRRL Report LR 1132 [1]. In the case of overlay design either a surface deflection method or the component overlay method should be used according to the type of pavement to be overlain.

4.2 Special cases

The design method described in clause **5** can be applied directly to the majority of flexible pavements. However, in some cases unusual or particularly onerous loading effects or other conditions should be taken into account, e.g. the following.

a) Where channelized traffic is expected, the traffic figures should be multiplied by three before carrying out the design, to allow for the increase in the concentrated application of loads at a particular location on the pavement. Normal lane widths in a highway do not generally constitute channelized traffic but channelized traffic can develop on any road, e.g. on steep hills, approaches to traffic signals and pinch points within traffic calming measures.

b) Where speeds in excess of 30 mile/h (50 km/h) are expected, the cumulative traffic should be multiplied by two before carrying out the design to allow for dynamic loading effects.

c) Where both channelized traffic and speeds in excess of 30 mile/h (50 km/h) occur only the higher multiplier, i.e. three, should be applied.

d) Pavements constructed over frost-susceptible soils should have an overall thickness of non frost-susceptible material of not less than 450 mm.

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e) Materials whose successful performance is dependent upon compaction being undertaken at critical moisture contents should only be used when engineering supervision can ensure that a stable construction can be achieved.

NOTE Some materials given in clause 804 of the Department of Transport *Specification for Highway Works*, 1986 edition, (see annex A) may fall into this category.

5 New pavement design

5.1 Subgrade assessment

The design California Bearing Ratio (CBR) should be obtained either by testing or by measurement of the plasticity index of the subgrade material. In the case of CBR testing, the method described in BS 1377-4:1990, clause **7** should be used.

The sample should be taken at subgrade level and tested at estimated long-term moisture content. In situations where it is possible that the subgrade will become saturated during part or all of the life of the pavement, the method employing the soaking procedure should be used. Alternatively, equilibrium suction index CBR values should be used. In the case of fine grained soils, the equilibrium suction index CBR can be determined from a knowledge of the plasticity index as shown in Table 1.

As effective subgrade drainage can have a significant effect on long-term CBR values, it should be considered during the design procedure.

NOTE 1 Filter drains set at the appropriate level and discharging to a satisfactory outfall or main drainage system have been found to perform satisfactorily.

On sites where the CBR varies from place to place, the lowest recorded values should be used or appropriate designs should be provided for different parts of the site using the lowest CBR recorded in each part.

NOTE 2 It may be possible to remove soft spots and therefore ignore those low CBR values which relate to the removed material.

Consideration should be given to using portable CBR measuring apparatus, some of which have been found to give sufficiently accurate results on fine grained soils when carried out at appropriate depths and moisture contents. It is often the case that a large number of CBR measurements undertaken with this type of apparatus is preferable to a relatively few measurements undertaken with the full scale in situ CBR measuring apparatus.

Table 1 — Equilibrium suction index CBR values

Type of soil	Plasticity index	High water table			Low water table		
		Construction conditions			Construction conditions		
		Poor	Average	Good	Poor	Average	Good
Heavy clay	70	1.5 to 2	2	2	1.5 to 2	2	2 to 2.5
	60	1.5 to 2	2	2 to 2.5	1.5 to 2	2	2 to 2.5
	50	1.5 to 2	2 to 2.5	2 to 2.5	2	2 to 2.5	2 to 2.5
	40	2 to 2.5	2.5 to 3	2.5 to 3	2.5	3	3 to 2.5
Silty clay	30	2.5 to 3.5	3 to 4	3.5 to 5	3 to 3.5	4	4 to 6
Sandy clay	20	2.5 to 4	4 to 5	4.5 to 7	3 to 4	5 to 6	6 to 8
	10	1.5 to 3.5	3 to 6	3.5 to 7	2.5 to 4	4.5 to 7	7 to >8
Silt	—	1 1	1 1	2 2	1 1	2 2	2 2
Sand (poorly graded)	—	20					
Sand (well graded)	—	40					
Sandy gravel (well graded)	—	60					

NOTE 1 This table indicates reasonable estimates of equilibrium values of CBR for combinations of poor, average and good construction conditions with high and low water tables. Good conditions pertain where the subgrade is protected promptly with a subgrade improvement layer or sub-base and the site is well drained with adequate falls. This results in subgrades never becoming wetter than their equilibrium moisture contents beneath the finished road. Poor conditions pertain where there is little or no subgrade protection and rainfall occurs on a poorly drained site so that the soil is fully wetted.

NOTE 2 A high water table is one 300 mm or less below formation level and is consistent with ineffective sub-soil drainage. A low water table is 1 m or more below formation level.

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Care should be exercised in the interpretation of site investigation data as the strength of soils is a function of their moisture content, the in-service strength may be much lower in soils than the recorded values in the site investigation. Care should also be exercised in using CBR values measured in summer as artificially high figures may be obtained due to the dryness of the soil.

Particular care should be exercised with soils having CBRs of 3 % or less. It should be recognized that BS 1377-9 requires that CBRs are quoted to the nearest whole figure, so that for very low CBRs the recorded value will be an approximation.

The surface of the subgrade material should be prepared according to clause 616 of the Department of Transport *Specification for Highway Works*, 1986 edition. In the case of silty clays, as the use of a vibrating roller may fluidize the material rather than compact it, a deadweight roller should be used.

Detailed preparation of the subgrade should be in accordance with the recommendations in BS 7533-3.

5.2 Design life

Design should take into account the cumulative amount of traffic which the pavement has to carry, measured either in terms of the number of commercial vehicles per day (cv/d), or the number of standard axles. Table 2 shows the relationship between commercial vehicles per day and million standard axles (msa) for design lives of 20 years and 40 years, in each case with zero growth and 2 % growth in traffic per annum.

A 20 year design life should generally be applicable unless access for possible maintenance of the roadbase is likely to be difficult or expensive. Where the pavement serves a finite area, zero growth in traffic is likely to be applicable, otherwise 2 % growth is recommended. If calculated growth figures are available these should be used to ascertain the number of standard axles. For special cases, reference should be made to **4.2**.

It may be necessary to reset the pavers during the life of a pavement if the rut depth exceeds 10 mm. This may be a result of displacement of the laying course sand and is not necessarily an indication of pavement failure. An inspection of the bound roadbase should be carried out prior to the relaying of pavers to ensure that no structural deterioration has occurred.

Displacement of laying course materials can occur in pavements for a variety of reasons. For example, pavements subjected to channelized trafficking, or particularly severe localized breaking or turning movements, may require resetting of the surfacing materials from time to time. Furthermore, areas where sustained heavy rainfall is common may develop surface undulations due to laying course sand movement well before the end of the pavement's structural design life. Laying course sand thickness should therefore not deviate from the values given in **5.3.6**.

Table 2 — Relationship between commercial vehicles per day and the number of standard axles for design lives of 20 years and 40 years at growth rates of 0 % and 2 % per annum

Volume of traffic	Cumulative traffic			
	20 years' design life		40 years' design life	
	Zero growth	2 % growth	Zero growth	2 % growth
cv/d	msa	msa	msa	msa
30	0.2	0.3	0.4	0.6
120	0.8	1	2	3
250	2	3	6	9
500	6	8	15[a]	22[a]
1 000	16[a]	22[a]	—[a]	—[a]

NOTE This table is based upon the normal spectrum of light to heavy commercial vehicles on a typical UK highway. Where the designer believes there is a greater proportion of light commercial vehicles than normal, these will be less damaging, hence more can be permitted. Conversely if a higher proportion are rear engined buses or heavy commercial vehicles fewer may be permitted and calculations based on axle damage factors are recommended, as described in TRRL Report LR 1132 [1].

[a] Volumes of traffic which exceed the scope of this British Standard.

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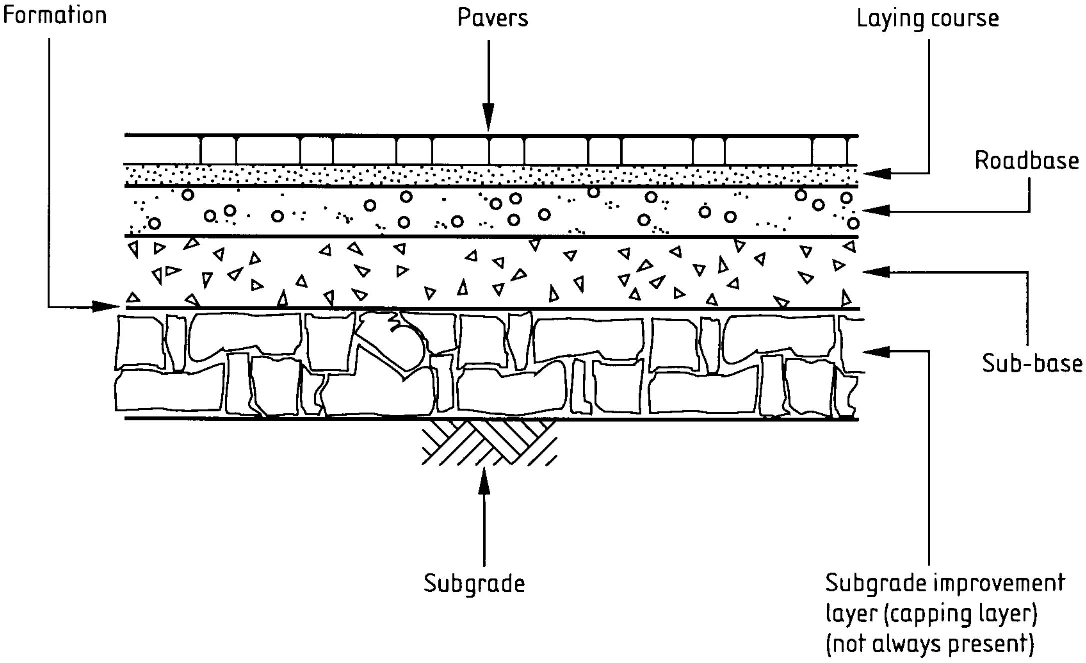

Figure 1 — Pavement cross-section

5.3 Selection of pavement components

5.3.1 *General*

The components of the pavement should be as illustrated in Figure 1. However, not all of the components need to be present in every pavement.

Design should proceed according to the flow charts shown in Figure 2a), Figure 2b) and Figure 3. Firstly the design CBR and the amount of traffic expected to use the pavement, expressed in million standard axles (msa), should be determined as described in **5.2**.

Engineering judgement should be used according to when, where and how the CBR was measured, local knowledge of the performance of the subgrade soils, the extent to which the subgrade improvement layer and sub-base will be trafficked, the proximity of subgrade drainage, and the likely time of year for construction.

The use of a subgrade improvement layer plus a sub-base [see Figure 2a)] or the use of a sub-base alone [(see Figure 2b)] results in pavement designs of equivalent structural performance. The choice of which design to use may be taken on economic, practical or other scheme specific criteria.

An example of the use of the design method for a new pavement is given in annex B.

5.3.2 *Subgrade improvement layer*

Subgrade improvement layer materials should provide a CBR in excess of 15 % on which to lay the sub-base, when designed according to the values given in Figure 2a).

5.3.3 *Sub-base*

If the sub-base is not to be used as an access road its thickness should be selected from the row entitled "Untrafficked" in Figure 2a). If a subgrade improvement layer is provided, the thickness of sub-base and subgrade improvement layer should be selected from the row entitled "Untrafficked" in Figure 2b).

If the road is to be used as an access road, the subgrade improvement (capping) layer and sub-base thickness may have to be increased as shown in Figure 2a) or Figure 2b) according to the amount of traffic which will travel directly over the sub-base. This should be determined in terms of either the number of standard axles trafficking the sub-base, the number of dwellings being constructed, or the equivalent size in square metres of the industrial or commercial property being constructed.

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In the case of sites which cannot be categorized in one of these three ways it should be assumed that the road will serve a large development trafficked by 5 000 standard axles. Engineering judgement should be used in assessing the amount of construction traffic to which the sub-base will be subjected.

The detailed preparation of the sub-base should be in accordance with the recommendations in BS 7533-3.

When rainfall is expected, it is expedient to cover the sub-base as quickly as possible to prevent saturation and also to protect the underlying materials. Remedial work may be required to the surface of a sub-base which has been used as a construction access road.

In circumstances when excessive trafficking of the sub-base causes rutting of the subgrade or contamination of the sub-base by subgrade material, the sub-base should be removed and remedial works to the subgrade should be conducted.

5.3.4 ***Preparation of roadbase and laying course***

The roadbase and laying course should be prepared in accordance with the recommendations in BS 7533-3.

5.3.5 ***Roadbase***

Figure 3 shows roadbase thickness for cement bound material (CBM) and dense bitumen macadam (DBM) 100 pen roadbases as defined in clauses 1 038 and 908 of the Department of Transport *Specification for Highway Works*, 1986 edition. Where a DBM 50 pen is available, in accordance with clause 929 of the *Specification for Highway Works*, 1986 edition, the thickness for DBM roadbase may be reduced by 15 %. DBM incorporating 200 pen binder should not be used as it is susceptible to deformation, but where unavoidable DBM thickness should be increased by 30 %. Engineering judgement should be used in the use of higher strength CBM3 in areas subject to differential movements.

In the case where there are fewer than 0.5 msa and the pavement does not fall into one of the special categories given in **4.2**, the pavement should be designed in accordance with BS 7533-2.

NOTE A minimum nominal roadbase thickness of 130 mm has been included in Figure 2 for practical construction reasons. Alternative roadbase thickness are given in Figure 2 for the relevant paver thickness.

5.3.6 ***Laying course***

The nominal thickness of laying course materials should be 30 mm.

5.3.7 ***Pavers***

Generally the paver thickness should be 50 mm, 60 mm, 65 mm or 80 mm (see Figure 3).

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Start

Determine design subgrade CBR and number of standard axles using sub-base as an access road

Foundation design option 2a)

Subgrade CBR design value	2 % or less [a,b]	> 2 % - < 3 % [a]	≥ 3 % - < 4 % [a]	≥ 4 % - < 5 %	≥ 5 % - < 10 %	≥ 10 % - < 15 %	≥ 15 % - < 30 %	30 % or greater
Untrafficked	150/150	150/150	Sub-base alone - see Figure 2b)					0/0
Up to four dwellings or 2 000m^2 commercial or standard axles (sa)	150/210	150/180	150/150	Sub-base alone - see Figure 2b)				0/0
Up to 20 dwellings or 200 sa	150/370	150/250	150/170	150/160	150/150	150/150	150/0	0/0
Up to 50 dwellings or 5 000m^2 commercial or 500 sa	150/470	150/340	150/250	150/220	150/200	150/150	150/0	0/0
Up to 80 dwellings or 8 000m^2 commercial or 1 000 sa	150/600	150/450	150/350	150/300	150/250	150/180	150/0	0/0
Large development or 5 000 sa	200/600	200/450	150/450	150/350	150/300	150/250	150/150	0/0

Go to Figure 3 for structural design

NOTE Sub-base and capping are shown thus: 150/350.

[a] Below 4 % a separating membrane is required.

[b] Heavy grade support mesh or fabric may be necessary to enable construction to proceed.

a) Capping and sub-base option

Figure 2 — New pavement design procedure — Foundation design

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Start

Determine design subgrade CBR and number of standard axles using sub-base as an access road

Foundation design option 2b)								
Subgrade CBR design value	2 % or less [a,b]	> 2 % - < 3 %[a]	≥ 3 % - < 4 %[a]	≥ 4 % - < 5 %	≥ 5 % - < 10 %	≥ 10 % - < 15 %	≥ 15 % - < 30 %	30 % or greater
Untrafficked	Figure 2a)	170	150	150	150	150	150	0
Up to 4 dwellings or 2 000m ^{2} commercial or standard axles (sa)	Figure 2a)	250	190	160	150	150	150	0
Up to 20 dwellings or 200 sa	Figure 2a)	310	240	210	180	150	150	0
Up to 50 dwellings or 5 000m ^{2} commercial or 500 sa	Figure 2a)	350	270	230	200	160	150	0
Up to 80 dwellings or 8 000m ^{2} commercial or 1 000 sa	Figure 2a)	400	310	270	225	180	150	0
Large development or 5 000 sa	Figure 2a)	450	350	310	270	240	225	0

Go to Figure 3 for structural design

[a] Below 4 % a separating membrane is required.
[b] Heavy grade support mesh or fabric may be necessary to enable construction to proceed.

b) Sub-base only option

Figure 2 — New pavement design procedure — Foundation design (*continued*)

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Design foundation to either Tables 2a) or 2b)

Add foundation to pavement structure determined as follows

Do any of the conditions in 4.2 apply? If so, apply the appropiate factors given in 4.2a) to c)

Determine cumulative standards axles (msa) for design

Design msa	0.5 to 1.5				> 1.5 to 4				> 4 to 8		> 8 to 12	
CBM3 roadbase thickness (in mm) or	130	130	130	130	160	150	145	130	195	180	245	230
Dense bitumen macadam roadbase 100 pen (in mm)	130	130	130	130	160	150	145	130	170	155	185	170
Laying course (in mm)	30	30	30	30	30	30	30	30	30	30	30	30
Paver thickness (in mm)	50[a]	60	65	80	50[b]	60	65	80	65	80	65[c]	80

End

[a] For clay pavers type PB and concrete pavers only.

[b] For clay pavers type PB only.

[c] There is no long-term evidence concerning the performance in service of 65 mm pavers beyond 4 msa, so this design information has been extrapolated.

Figure 3 — New pavement design procedure — Structural design for roadbase and surfacing

6 Pavement course specification

6.1 Materials

In general the pavement construction materials should be specified according to the relevant clauses of the Department of Transport *Specification for Highway Works*, 1986 edition, shown in Table 3.

6.2 Laying course and jointing material

The laying course and jointing material should be in accordance with the recommendations given in BS 7533-3.

6.3 Pavers

Clay pavers should conform to BS 6677-1 and concrete block pavers should conform to BS 6717-1.

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Table 3 — *Specification for Highway Works* clauses (see annex A)

Category of material	Clause number
Cement bound material 1	1 036
Cement bound material 2	1 037
Cement bound material 3	1 038
Cement bound material 4	1 039
Pavement quality concrete	1 001 to 1 034
Dense bitumen macadam	908/929
Hot rolled asphalt	904
Type 1 granular sub-base material	803
Type 2 granular sub-base material	804
Wet mix macadam	805
Subgrade improvement material	613

7 Pavement overlay design

7.1 Selection of method

Overlay design should be undertaken in one of two ways, either by using a method based on elastic deflection or by using a component overlay design method. The deflection-based method should be used when existing flexible roads are to be overlain. When other types of roads or industrial areas are to be overlain, the component overlay method should be used.

7.2 Deflection beam method

7.2.1 In the deflection beam method, described in TRRL Reports LR 833 [2], LR 834 [3] and LR 835 [4], it is assumed that the overlay material will be a bituminous bound material. By taking the material conversion factors (MCFs) given in Table 4, the method described in the reports can be adapted to overlaying with clay or concrete block pavers. When the method indicates that a 110 mm thickness or less of dense bitumen macadam (DBM) or hot rolled asphalt is required as the overlay, clay or concrete block pavers can be used with safety. When it is found that a greater thickness than 110 mm is required, an additional layer of bound material should be provided together with the pavers.

7.2.2 The minimum thickness of materials and the nominal sizes of aggregates used in overlays should conform to BS 594-1 and BS 594-2, and BS 4987-1 and BS 4987-2.

7.3 Component overlay design method

7.3.1 *Evaluation of existing pavement*

7.3.1.1 *General*

In the component overlay design method, the condition of each course in an existing pavement should be expressed as an equivalent thickness of a standard material. This allows the current condition of dilapidated materials to be assessed numerically. The standard material chosen should be dense bitumen macadam 100 pen (see the *Specification for Highway Works*). The method should be operated as described in **7.3.1.2** to **7.3.1.4**.

7.3.1.2 *Preparation*

The thickness and condition of each course of the existing pavement should be determined.

NOTE It is usually necessary to undertake trial excavations or to take cores.

7.3.1.3 *Material conversion factor (MCF)*

Once each type of material within the pavement is identified, an MCF (see Table 4) should be assigned to that material. The true thickness of each course in the pavement should then be multiplied by the appropriate MCF to obtain the equivalent thickness of DBM.

The equivalent thickness of pavers is given in Table 5.

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Table 4 — Material conversion factors (MCFs) for evaluating highway pavement materials

Category of material	Material conversion factor (MCF)	
	Suggested value	Range
Cement bound material 1 (CBM1)	0.4	0.2 to 0.6
Cement bound material 2 (CBM2)	0.5	0.3 to 0.7
Cement bound material 3 (CBM3)	0.7	0.5 to 0.9
Cement bound material 4 (CBM4)	0.7	0.5 to 0.9
Pavement quality concrete	1.7	1.5 to 1.9
Dense bitumen macadam (100 pen)	1.0	0.9 to 1.1
Hot rolled asphalt	1.0	0.9 to 1.1
Open textured macadam	0.7	0.5 to 0.9
Wet-mix or dry-bound macadam	0.45	0.3 to 0.6
Type 1 granular sub-base material over material with a CBR of >5 %	0.3	0.15 to 0.4
Type 1 granular sub-base material over material with a CBR of >5 %	0.2	0.1 to 0.25
Type 2 granular sub-base material over material with a CBR of >5 %	0.2	0.1 to 0.25
Type 2 granular sub-base material over material with a CBR of −5 %	0.1	0.05 to 0.15
Subgrade improvement material	0.1	0.05 to 0.15
NOTE The suggested values in this table relate to the stated materials in their common situations. In unusual situations, alternative values may be substituted but will generally not depart from the range. Departures from the suggested values will occur only when there is a specific reason for change.		

Table 5 — Equivalent thickness of pavers and laying course

Paver thickness mm	Pavement laying course mm	DBM (100 pen) equivalence mm
80	110	120
65	110	105
60	110	100
50	110	90

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7.3.1.4 *Condition factors*

In order to account for any degradation which may have taken place in each course of the pavement since it was first constructed, the equivalent thickness of each course should be multiplied by two condition factors (CF1 and CF2) which account for the less than perfect condition of the material in the pavement. CF1 should be applied to take account of cracking and spalling of the pavement materials and CF2 should be applied to account for rutting and settlement.

NOTE If the deterioration of the surface or roadbase is a result of failure in the sub-base, the subgrade improvement layer or the subgrade, it may not be possible to overlay the existing pavement.

CF1 and CF2 should be determined for each course in the existing pavement according to the condition of the material as shown in Tables 6 and 7.

For consistent results these factors should be applied by engineers with a working knowledge of a recognized pavement assessment system.

If the rut depth is greater than 20 mm, the condition of the road foundation should be investigated to determine whether subsurface drainage has been damaged.

7.3.1.5 *Determination of feasibility of overlaying directly*

Once the existing pavement has been transformed into an equivalent thickness of DBM, a pavement should be designed in accordance with the method described in clause **5** and that theoretical pavement should be transformed into an equivalent thickness of DBM using the material conversion factors given in Table 4. By comparing the equivalent thickness of DBM in the existing pavement with the equivalent thickness of DBM required for the new pavement, a determination can be made as to whether the provision of a clay or concrete block paver overlay will provide a satisfactory engineering solution. It may be that an additional course of material should be provided beneath the clay or concrete block pavers in order to bring the overlain pavement to a satisfactory structural condition.

NOTE 1 Although some of the materials in Table 4 are not currently generally used or specified, it is possible that they will be encountered in an existing pavement.

In the case of condition factor CF1, a degree of judgement is required in establishing the condition of the material, especially for those courses beneath the surface. If there is no alternative evidence it can be assumed that the materials beneath the surface are in a similar condition to those at the surface.

NOTE 2 It should be noted that a full investigation of the original pavement can often lead to greater structural adequacy being assumed for the pavement to be overlain. Often this can make the difference between the possibility of directly overlaying with clay or concrete block pavers and not being able to use this procedure.

If the levels or required falls for the finished surface after paving are different from those of the existing surface, planing out or regulation with appropriate bituminous material will be required. The effect of such removal or addition should be taken into account during the evaluation for overlaying. It is important that the surface on which laying course material is laid should be such as to ensure a uniform thickness of laying course material everywhere.

A worked example showing how the component overlay design method can be used is given in annex C.

Table 6 — Condition factor CF1

Condition of material	CF1
As new	1.0
Slight cracking	0.8
Substantial cracking	0.5
Fully cracked, or crazed and spalled	0.2

Table 7 — Condition factor CF2

Degree of localized rutting or localized settlement mm	CF2
0 to 10	1.0
11 to 20	0.9
21 to 40	0.6
41 and above	0.3

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Annex A (informative)

Specification for Highway Works clauses

The following clauses from the Department of Transport *Specification for Highway Works*, 1986 edition, are referred to in this British Standard:

Clause number:	613;
	616;
	803;
	804;
	805;
	904;
	908;
	929;
	1 001 to 1 034 inclusive;
	1 036 to 1 039 inclusive.

Annex B (informative)

Example of the use of the design method for a new pavement

A new shopping development of 4 500 m^2 will be served by an access road, which will be trafficked by the typical UK traffic mix with an initial 250 commercial vehicles per day after opening. Traffic growth is estimated at 2 % over the 20 year design life of the pavement. The speed limit on the new road will be 40 mile/h (65 km/h). During construction the road sub-base will be used for site access. The CBR of the subgrade is 4 %.

Design of the pavement in pavers proceeds as follows:

Step 1. Using Figure 2a) and the subgrade CBR of 4 %, as the sub-base is to be used for site access for a commercial development of 4 500 m^2, a subgrade improvement layer of 220 mm and a granular sub-base layer of 100 mm thick is needed.

Step 2. Table 2 indicates that a traffic volume of 250 commercial vehicles per day with a 2 % growth rate will result in cumulative traffic of 3 msa using the road over a 20 year design life. This assumes that the normal UK traffic mix uses the access road.

Step 3. **4.2** states that where speeds in excess of 30 mile/h (50 km/h) are anticipated [this road will have a 40 mile/h (65 km/h) speed limit] the cumulative traffic using pavement should be multiplied by two, i.e. the 3 msa in step 3 will become 6 msa.

Step 4. 6 msa falls into the 4 msa to 8 msa bracket of Figure 3. This gives two alternatives, depending on the thickness of paver selected.

The alternative pavement construction solutions are as follows:

Subgrade improvement layer	220 mm	or	220 mm
Granular sub-base — Type 1	100 mm	or	100 mm
CBM 3 roadbase	180 mm	or	195 mm
or			
Dense bitumen macadam (100pen) roadbase	155 mm	or	170 mm
Laying course	30 mm	or	30 mm
Paver	80 mm	or	65 mm

Using Figure 2b): a granular sub-base layer alone of 230 mm is needed. It is decided to proceed on this site with the option of using a subgrade improvement layer.

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Annex C (informative)
Example of the use of the component overlay design method

Consider an overlay to an existing road with 65 mm thick pavers on 30 mm laying course sand. The existing pavement construction is as given in Table C.1.

Table C.1 — Existing pavement construction

Thickness mm	Construction
75	Hot rolled asphalt substantially cracked, 15 mm ruts
80	DBM, substantially cracked, 15 mm ruts
150	Pavement quality concrete, slightly cracked, no rutting
150	Type 2 sub-base material, no cracking, no rutting
	2 % CBR subgrade
455	Total actual thickness

The overlain pavement is required to withstand 2 msa.

Step 1. Using Figure 2a) and Table 5 develop a design for a new road construction for the appropriate CBR and trafficking to be expressed as the structural dense bitumen macadam equivalence thickness.

The structural DBM equivalence is obtained as given in Table C.2.

Step 2. The existing pavement with paver overlay is evaluated as shown in Table C.3.

The original pavement with a paver overlay is structurally equivalent to 394 mm of new DBM. A pavement to withstand the anticipated trafficking on the soil conditions described requires the equivalent of 287 mm of new DBM. Therefore, a paver overlay is feasible.

Table C.2 — Structural DBM equivalence

Course	Layer thickness mm	MCF	DBM equivalence mm
65 mm pavers on 30 mm laying course sand	95	See Table 5	105
CBM3	130	0.7[a]	102
Type 1 granular sub-base material	150	0.3[a]	45
Subgrade improvement layer	150	0.1[a]	15
		Total:	267

[a] See Table 4.

Table C.3 — Paver overlay

Course	Layer thickness mm	MCF	Condition factor CF1[a]	Condition factor CF2[b]	DBM equivalence mm
Paver overlay	95	See Table 5			105
Hot rolled asphalt	75	1.0[c]	0.5	0.9	34
Dense bitumen macadam	80	1.0[c]	0.5	0.9	36
Pavement quality concrete	150	1.7	0.8	1.0	204
Type 2 granular sub-base material	150	0.1[c]	1.0	1.0	15
				Total:	394

[a] See Table 6.
[b] See Table 7.
[c] See Table 4.

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