BS 7533-10:2010

BSI Standards Publication

Pavements constructed with clay, natural stone or concrete pavers –

Part 10: Guide for the structural design of trafficked pavements constructed of natural stone setts and bound construction with concrete paving blocks

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Contents

Summary of pages

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Foreword

Publishing information

This part of BS 7533 is published by BSI and came into effect on 30 April 2010. It was prepared by Technical Committee B/507, *Paving units, kerbs, screeds and in-situ floorings*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 7533 supersedes BS 7533-10:2004, which is withdrawn.

Relationship with other publications

BS 7533 consists of 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 6: Code of practice for laying natural stone, precast concrete and clay kerb units;*
- *Part 7: Code of practice for the construction of pavements of natural stone paving units and cobbles, and rigid construction with concrete block paving;*
- *Part 8: Guide for the structural design of lightly trafficked pavements of precast concrete flags and natural stone flags;*
- *Part 9: Code of practice for the construction of rigid pavements of clay pavers;*
- *Part 10: Guide for the structural design of trafficked pavements constructed of natural stone setts and bound construction with concrete paving blocks;*
- *Part 11: Code of practice for the opening, maintenance and reinstatement of pavements of concrete, clay and natural stone;*
- *Part 12: Guide to the structural design of trafficked pavements constructed on a bound base using concrete paving flags and natural stone slabs;*
- *Part 13: Guide for the design of permeable pavements constructed with concrete paving blocks and flags, natural stone slabs and setts and clay pavers.*

Information about this document

This is a full revision of the standard, which has been updated to include guidance for the structural design of trafficked pavements constructed of concrete paving blocks in a bound surface course.

Presentational conventions

The word "should" is used to express recommendations of this standard. The word "may" is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the Clause. The word "can" is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This part of BS 7533 provides guidance on the design of pavements surfaced with paving units of:

a) natural stone setts manufactured in accordance with BS EN 1342 and laid in accordance with BS 7533-7; and

b) concrete paving blocks conforming to BS EN 1338 and laid in a bound surface course in accordance with BS 7533-7.

It applies to all pavements including those subjected to commercial vehicular traffic, e.g. delivery vehicles.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 6100-3, *Building and civil engineering - Vocabulary – Part 3: Civil engineering – General*

BS 7533-1, *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*

BS 7533-2, *Pavements constructed with clay, natural stone or concrete pavers – Part 2: Guide for the structural design of lightly trafficked pavements constructed of clay pavers or precast concrete paving blocks*

BS 7533-4:2006, *Pavements constructed with clay, natural stone or concrete pavers – Part 4: Code of practice for the construction of pavements of precast concrete flags or natural stone slabs*

BS 7533-7:2010, *Pavements constructed with clay, natural stone or concrete pavers – Part 7: Code of practice for the construction of pavements of natural stone paving units and cobbles, and rigid construction with concrete block paving*

BS EN 13108-1, *Bituminous mixtures – Material specifications – Part 1: Asphalt concrete*

BS EN 1342:2001, *Setts of natural stone for external paving – Requirements and test methods*

BS EN 13877-1, *Concrete pavements – Part 1: Materials*

[1] HIGHWAYS AGENCY. Manual of Contract Documents for Highway Works, Volume 1: Specification for Highway Works, London: The Stationery Office.

3 Terms and definitions

For the purposes of this part of BS 7533, the terms and definitions given in BS 6100-3 and the following apply.

3.1 base

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

[BS 7533-1:2001, definition **3.6**]

NOTE 1 Figure 1 illustrates a typical cross-section of a pavement.

3.2 bound surface course
surface course where the paving units are laid on a laying course of fine concrete and the joints are filled with a cement mortar or grout

3.3 cement bound material (CBM)
granular material to which cement has been added

[BS 7533-2:2001, definition **3.7**]

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

[BS 7533-1:2001, definition **3.7**]

NOTE This can occur in narrow entrances such as gates or induced traffic calming measures and sharp bends where the running lane is below 3 m in width. Normal lane widths in a highway do not generally constitute channelized traffic.

3.5 commercial vehicle
vehicle with an unloaded weight of >1.5 t

3.6 concrete paving block (CPB)
precast concrete unit used as a surface course that satisfies the following conditions:

– at a distance of 50 mm from any edge, any cross-section does not show a horizontal dimension less than 50 mm;

– its overall length divided by its thickness is less than or equal to four.

NOTE These two conditions are not applicable to complementary fittings.

3.7 cumulative traffic
number of standard axles a pavement is designed to carry, measured in standard axles per day

3.8 foundation
sub-base, base and laying course layers of a pavement

NOTE The base layer can be the sub-base layer where it is an unbound non-rigid base.

3.9 laying course
layer of material on which paving units are bedded

[BS 7533-1:2001, definition **3.2**]

NOTE See Figure 1.

3.10 non-rigid base
base consisting of unbound aggregate, non-rigid bitumen macadam or non-rigid asphalt

NOTE A non-rigid base layer can be the same layer as the sub-base if no separate base is provided.

3.11 pavement
paved area subject to pedestrian and/or vehicular traffic

[BS 7533-2:2001, definition **3.4**]

3.12 pavement quality concrete (PQC)
concrete layer capable of withstanding direct passage of traffic and environmental effects

3.13 paving unit
natural stone sett or concrete paving block

3.14 rigid bound base
base consisting of stiff bituminous or asphalt material or a cement bound material

3.15 sett
paving unit manufactured of natural stone

NOTE 1 A sett can be designated a cube sett (C) or sett (S) depending upon its plan dimension. Setts are generally less than 300 mm × 300 mm in plan dimension.

NOTE 2 Setts may be sawn or cropped.

NOTE 3 The upper face of cropped setts might be dressed to remove irregularities and/or to enhance slip resistance. The upper face of sawn setts might be textured to enhance slip resistance.

3.16 shallow sett
sett having the depth less than the width but not less than half the width of the sett

3.17 standard axle
axle carrying a load of 8 200 kg

3.18 sub-base
one or more layers of material placed immediately above the subgrade

[BS 7533-1:2001, definition **3.5**]

NOTE See Figure 1.

3.19 subgrade
upper part of the soil, natural or constructed, that supports the loads transmitted by the overlaying road structure

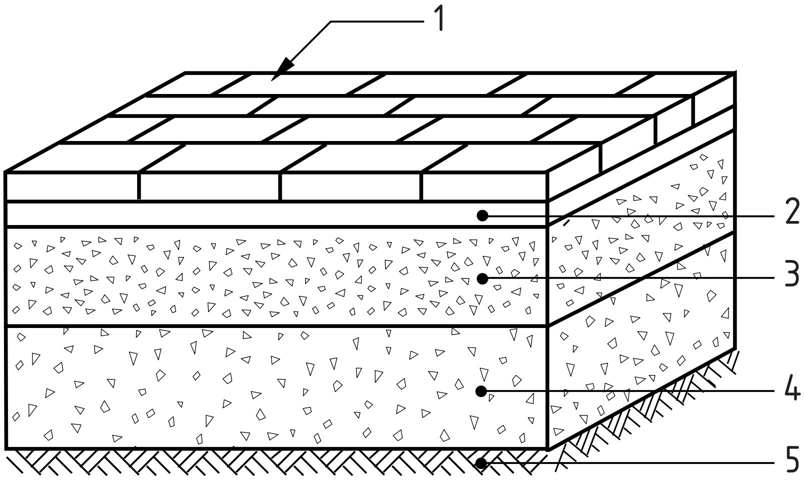
[BS 7533-2:2001, definition **3.3**]

NOTE See Figure 1.

3.20 surface course
surface of the pavement used by vehicles and/or pedestrians constructed of paving units laid with filled joints

3.21 unbound surface course
surface course where paving units are laid on a laying course of fine aggregate, which has no binder added, and the joints are filled with fine aggregate with no binder added

Figure 1 **Typical cross-section of a pavement**



Key

1 Surface
2 Laying course
3 Roadbase
4 Sub-base
5 Subgrade

4 General design criteria

4.1 Basis of structural design

4.1.1 Design options

The design options provided in this standard include the following:

a) an unbound surface course laid upon a non-rigid unbound base; or

b) an unbound surface course laid upon a non-rigid bound base; or

c) a bound surface course laid upon a rigid bound base.

A design option for a bound surface course laid upon a non-rigid base is not provided since the stresses on the jointing material resulting from pavement deflection under traffic are such that durability cannot be assured.

NOTE 1 Guidance on the appropriateness of each design option is given in the relevant clause. Examples of the use of the design methods given in this standard are given in Annex A.

The designer should select the preferred surface course option and paving unit size then carry out a structural design for the traffic level and subgrade bearing strength of the site (see Clause **5** and Clause **6**).

If an acceptable design with the selected surface course is not possible or economic, an alternative surface course option should be selected and the design process repeated.

NOTE 2 For an unbound surface course laid upon a non-rigid base, the chosen thickness of the pavement is directly related to the number of commercial vehicles the pavement carries over its lifespan. For a bound surface course laid on a rigid bound base, the structural performance is affected by fatigue and one-off overload, or by repeated loading from a small number of commercial vehicles, which can cause a failure in the jointing material itself or a failure of the bond between the jointing material and the unit.

4.1.2 Site categories

For the purposes of design, pavements should be categorized according to the commercial vehicular traffic assessment shown in Table 1.

Access ways to commercial and business premises and public buildings should be placed in site category I, II or III depending upon the estimate of the total commercial vehicular traffic likely to use the pavement (see **6.3**).

Site category IV should only be selected where it can be ensured that no commercial vehicles use the pavement, e.g. where bollards have been installed.

In determining the site category, the use of the surface of the pavement by any construction traffic should be assessed and allowed for.

Table 1 **Site categories for typical applications**

Site category	Standard axles per day	Typical applications
IB	>1000	Adopted highways and commercial developments used by a high number of commercial vehicles
IA	</= 1000	
I	</=200	
II	</=60	Adopted highways and other roads used by a moderate number of commercial vehicles Petrol station forecourts Pedestrian projects subjected to regular overrun of commercial vehicles
III	</=5	Adopted highways and other roads used by a low number of commercial vehicles, e.g. cul-de-sac on a housing development Pedestrian projects subjected to occasional overrun of commercial vehicles Car parks receiving occasional commercial vehicular traffic Footways regularly overridden by commercial vehicular traffic
IV	0	Car parks receiving no commercial vehicular traffic Footways subjected to domestic vehicular crossover Private drives, paths, patios, hard landscaping Areas receiving pedestrian traffic only, e.g. school playgrounds

4.1.3 Special cases

Where dynamic and/or impact loading occurs, (e.g. on traffic calming ramps, or where a row of paving units is laid with its surface not flush with the surrounding pavement, or for sites subjected to braking or turning, or where there are steep hills) consideration should be given to introducing high horizontal tensile stresses into the pavement. The structural design in terms of vertical loading should remain unchanged. However, before carrying out the design the number of standard axles using a site per day, determined in accordance with **6.3**, should be multiplied by two to allow for the higher horizontal tensile stresses. The site category of a site experiencing high horizontal tensile stresses should be determined in accordance with Table 1 after the value for the number of standard axles per day has been doubled.

Lateral edge restraints and intermediate restraints appropriate to the site category should be used (see BS 7533-7:2010, Annex D). Patterns should be arranged so that traffic does not run along continuous joints.

A combination of the following design options should be considered so that the site is able to resist the higher tensile stresses:

a) A paving unit type and size that offers higher loading capacity in the highly stressed area.

b) A laying pattern that increases interlock between the elements in unbound paving, e.g. arc patterns.

c) An increased frequency of lateral edge and intermediate restraint.

d) Where the standard axles are >200 and <1 000, size 4 full sett should be used.

e) Where the standard axles are >1 000 and the depth of the sett should be at least 20% greater than the width.

4.2 Skid resistance and abrasion resistance

The slip/skid resistance of the surface of natural stone setts should be determined to ensure adequate safety against skidding and slipping when new or in service. Guidance on the determination of the unpolished slip resistance value is given in BS 7932.

The abrasion resistance of the surface of natural stone setts should be determined in accordance with BS EN 1342 to ensure durability and the performance of the surface.

5 Materials

5.1 Foundation materials

In unbound pavement construction, the successful performance of the sub-base and/or base, laying course and jointing materials are dependent upon compaction being undertaken at critical moisture contents. In rigid bound pavement construction, the successful performance of the sub-base, base, laying course and jointing materials are dependent on achieving a specified strength and stiffness. The recommendations given in **5.2**, **5.3**, **5.4** and **5.5** for the materials used in the foundation of the pavements reflect this distinction.

Pavements in site categories II and III, where the overall design thickness is thin, may be constructed over frost-susceptible soils and may require the overall thickness of non frost-susceptible material to be increased to a value suitable for the locality (see also **6.1**).

5.2 Sub-bases

Sub-bases for both non-rigid and rigid pavements should be constructed from Type 1 sub-base in accordance with Clause 802 of the *Highways Agency's Specification for Highway Works* [1].

5.3 Base materials

For non-rigid unbound base (see Table 6), Type 1 sub-base in accordance with the appropriate clauses of the *Highways Agency's Specification for Highway Works* [1] should be used.

NOTE 1 Sub-base materials conforming to Clause 804 (Type 2) is inappropriate.

NOTE 2 A non-rigid unbound base layer can be the same layer as the sub-base if no separate base is provided.

In unbound systems, designers should take into account the requirement for water permeability of the sub-base.

For non-rigid bound base (see Table 6), any of the following binder course mixtures specified in BS EN 13108-1 should be used:

a) 0/20 mm size open graded binder course with bitumen grade 40/60 pen;

b) 0/20 mm AC 20 (DBM) 40/60 designed binder course;

c) 0/20 mm AC 20 (DBM) 100/150 recipe binder course for site category III and IV only.

For rigid bound base (see Table 7) comprising of pavement quality concrete (PQC), the material should conform to BS EN 13877-1 concrete strength class 32/40.

For rigid bound base (see Table 7) any of the following binder course mixtures specified in BS EN 13108-1 should be used:

1) 0/20 mm AC 20 (DBM) 100/150 designed binder course for site categories III and IV;

2) 0/20 mm AC 20 (DBM) 40/60 recipe binder course for site categories I, II, III and IV.

For non-rigid bound base (see Table 6) and rigid bound base (see Table 7) comprising cement bound material (CBM), the concrete should have a minimum compressive strength of 15 N/mm^2 when measured in accordance with BS 7533-7. A non-rigid bound or rigid bound base layer should be water permeable to allow the free drainage of water from the laying course. Where dense material is used, adequate falls and suitable perforation to provide adequate permeability at the base should be provided.

NOTE 3 In unbound construction it is important that the laying course material does not become saturated in service.

5.4 Laying course material

5.4.1 Unbound surface course

The laying course material used in unbound construction should conform to the recommendations for sawn and cropped setts given in BS 7533-7:2010, **C.1**.

Fine aggregate material for laying courses used in unbound construction should be the same as the jointing material (see **5.6**).

5.4.2 Bound surface course

The laying course material used in bound construction should conform to the recommendations for fine bedding concrete specified in BS 7533-7:2010, **C.2.1** and BS 7533-4:2006, **5.4.4.2**.

5.5 Surface course materials

5.5.1 General

Setts should conform to BS EN 1342 and may:

a) be sawn on all six sides;

b) have sawn edges and a cropped or riven upper and/or lower surface;

c) have cropped or riven edges and a sawn upper and/or lower surface; and/or

d) be cropped on all six sides.

The deviation from nominal thickness should be in accordance with Class 2 of BS EN 1342:2001, Table 2. Freeze–thaw resistance should be in accordance with Class 1 of BS EN 1342:2001, Table 4.

BS EN 1342 requires the supplier to declare the value of compressive strength.

Depending upon the application, BS EN 1342 may require abrasion resistance and slip/skid resistance of setts to be declared (see 4.2).

For the purposes of design, the size of setts should be classified as given in Table 2. The depth of the sett is a minimum. Setts with a greater depth may be used if required [see **4.1.3**e)].

Table 2 **Sett size categories**

Category	**Plan dimensions**		**Min. depths**		**Design joint width** mm
	Max. width mm	**Max. length** mm	**Full setts** mm	**Shallow setts** mm	
Size 1	50	100	50	—	6–10
Size 2	80	160	80	40	8–12
Size 3	100	200	100	50	8–12
Size 4	150	300	150 [A)]	75	10–15

NOTE To calculate the minimum thickness of stone setts having lengths greater than stated; use the appropriate equation in BS EN 1341:2001, Annex B.

A) Setts with a increased depth have a minimum depth of 180 mm.

5.5.2 Sawn setts

Where sawn sett dimensions fall within the dimensional tolerances specified for clay pavers in BS EN 1344 and concrete paving blocks in BS EN 1338, generally ±2 mm on plan dimensions, and can be laid to achieve the required degree of interlock, then they should be designed as a flexible surface as described in BS 7533-1 and BS 7533-2. This allows the material to be used in a higher category of loading (see Table 1 and Clause **6**).

Where sawn side setts are used for an unbound surface course, the side faces should be textured, i.e. rough sawn, to ensure good friction characteristics between the setts and the fine aggregate jointing material.

Where sawn side setts are used for a bound surface course, the side faces should be cleaned, i.e. pressure washed or scrubbed, to ensure good adhesion between the setts and the jointing and bedding concrete. Where jointing and bedding concrete is used, the level of adhesion should be tested in accordance with BS 7533-7.

5.6 Jointing materials

5.6.1 Unbound surface course

Jointing materials for an unbound surface course should be selected in accordance with BS 7533-7:2010, **C.1**.

NOTE Stabilized aggregates which employ a visco-elastic binder might be suitable for site category IV and may be used at the discretion of the specifier using the design criteria for unbound construction.

5.6.2 Bound surface course

The compressive strength of jointing materials for a bound surface course should be selected from Table 3 and conform to BS 7533-7:2010, **C.2.2**. Jointing materials with compressive strengths of 25 N/mm^2 and 40 N/mm^2 should conform to the additional jointing mortar recommendations given in BS 7533-7:2010, **C.2**.

Table 3 **Bedding and jointing mortar strength**

Site category (see Table 1)	**Min. sett size category** (see Table 2 and **4.1.3**)		**Min. concrete block paving thickness**	**Bedding mortar designation according to BS 7533-7**	**Compressive strength of the joint**
	Shallow setts	**Full setts**	mm		N/mm^2
IA (special case)	—	Size 4 with increased depth	—	Type B	40
IB (special case)	—	Size 4	—	Type B	40
I	Size 4	Size 3	80	Type B	40
		Size 4	—	Type A	40
II	Size 3	Size 2	80	Type B	40
		Size 3	—	Type A	40
		Size 4	—	Type A	25
III	Size 3	Size 1	50	Type B	40
		Size 3	80	Type A	25
IV	Size 2	—	—	Type B	40
		Size 1	50	Type A	25

6 Design

6.1 Subgrade assessment

The design should be based upon an assessment of the subgrade bearing strength, which is described as the California Bearing Ratio (CBR). The weaker the subgrade, the stronger the pavement required.

The design CBR should be obtained by measuring the plasticity index or defining the material description of the subgrade and then consulting Table 4.

*NOTE 1 BS 7533-1:2001, **5.1** gives further recommendations on the assessment of subgrade bearing strength.*

Table 4 **CBR values for different material**

Type of soil	Plasticity index	Estimated CBR %
Heavy clay	70	2
	60	2
	50	2
	40	3
	30	4
Silty clay	20	5
Sandy clay	10	5
Silt	Not applicable	1
Sand poorly graded	Not applicable	20 (7) [A)]
Sand well graded	Not applicable	40 (10) [A)]
Sandy gravel	Not applicable	60 (15) [A)]

A) The bracketed figures to be considered if these materials are likely to become saturated in service.

Table 4 is intended for use where the water table is 300 mm or more below formation level. In other conditions, specialist advice should be sought.

Effective subgrade drainage should be considered during the design procedure since this can have a significant effect on long-term CBR values.

NOTE 2 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.

Soft spots should be removed, and replaced with material having an appropriate CBR.

Care should be taken in the interpretation of site investigation data. In the case of subgrades, where strength is a function of their moisture content, the in-service strength can be much lower than the recorded values. Care should also be taken in using CBR values measured in summer because artificially high figures can be obtained due to dryness of the soil.

For site category IV loading only (see Table 1), subgrade strength should be estimated by carrying out the field test given in Annex B after the initial compaction of the trimmed ground.

6.2 Foundation thickness

Foundation thickness should be in accordance with Table 5, Table 6 and Table 7 for the different site categories.

Table 5 **Foundation thickness and sett type – Unbound surface course, non-rigid unbound base**

Site category	Min. compacted sub-base/unbound base thickness mm					Nominal compacted laying course thickness mm	Min. sett size category A)
	Design CBR						
	2%	3%	4%	5%	6%		
I, IA and IB	Not applicable					Not applicable	Not applicable
II	Not applicable					40	Size 3 - Full sett
III	500	450	375	300	250	40	Size 2 - Full sett

A) Sett size categories are given in Table 2.

Table 6 **Foundation thickness and sett type – Unbound surface course, non-rigid bound base**

Site category	Min. compacted sub-base thickness mm					Nominal compacted thickness mm		Min. sett size category A)
	Design CBR					Bituminous, asphaltic and cement bound base	Laying course	
	2%	3%	4%	5%	6%			
I, IA and IB	Not applicable					Not applicable		Not applicable
II	300	275	250	225	175	160	40	Size 3 - Full sett
III	300	275	250	225	175	120	40	Size 2 - Full sett
IV	300	250	200	110	110	Not applicable	40	Size 1 - Full sett

A) Sett size categories are given in Table 2.

Table 7 **Foundation thickness and sett type – Bound surface course, rigid bound base**

Site category	Min. compacted sub-base thickness mm					Nominal compacted thickness mm		Min. sett size category
	Design CBR					Bituminous, asphaltic and cement bound base	Cement bound (CBM) concrete (PQC)	
	2%	3%	4%	5%	6%			
IA (special case)	450	350	250	150	150	200	150 PQC	Size 4 - Full sett with increased depth
IB (special case)	450	350	250	150	150	200	150 PQC	Size 4 - Full sett
I	450	350	250	150	150	200	200 CBM	Size 3 - Full sett
						Not applicable	150 PQC	Size 4 - Shallow sett
II	300	275	250	150	150	200	200 CBM	Size 2 - Full sett
						Not applicable	150 PQC	Size 3 - Shallow sett
III	300	275	250	150	150	200	150 CBM	Size 2 - Full sett
						Not applicable	150 PQC	Size 3 - Shallow sett
						Not applicable	150 PQC	Size 1 - Full sett
IV	300	250	200	110	110	40	100 CBM	Size 1 - Full sett
						Not applicable	120 PQC	Size 2 - Shallow sett

The laying course thickness after sett compaction should be 40 mm for moist bedding and 30 mm for plastic bedding in accordance with BS 7533-7:2010, **8.5.1**.

6.3 Evaluation of traffic

The design for both non-rigid and rigid pavement construction should take into account the cumulative traffic the pavement has to carry, including construction traffic, measured in terms of the number of standard axles per day.

The type of commercial vehicles using the pavement will be mixed. Therefore, the number of standard axles per day should be determined by estimating the daily amount of each type of commercial vehicle using the pavement and then converting these figures to standard axles using the conversion factors given in Table 8.

The potential for growth of traffic over the intended design life of the pavement should be considered.

The design for both unbound and bound pavement construction should also take account of channelized traffic or dynamic/impact loading if applicable (see **4.1.3**). In the case of a bound surface course, a one-off overload can cause failure and should be taken into account in the design.

With an unbound surface course it can be necessary to reset the paving units during the life of a pavement. This can be a result of displacement of the laying course material and is not necessarily an indication of pavement failure.

Table 8 **Standard axles per commercial vehicle**

Vehicle type	Conversion factor
Buses and coaches	2.6
2 axle rigid	0.4
3 axle rigid	2.3
3 axle articulated	1.7
4 axle rigid	3.0
4 axle articulated	1.7
5 axle articulated	2.9
6 axles or more	3.7

NOTE For more details of the traffic calculation see HD24/06 [2].

6.4 Structural design

6.4.1 Foundation design – Unbound surface course

The contribution of an unbound surface course to the structural strength of the pavement as a whole can be quite small. It is, however, important that the surface course provides a stable and durable layer by the correct selection of sett size and correct installation.

Where an unbound surface course is formed from setts sawn on all edges these should be laid on an unbound bedding course, bedded down using a vibrating compactor and jointed with dry fine aggregate in accordance with BS 7533-7.

Where an unbound surface course is formed from cropped setts, these should be laid and jointed with crushed rock fines in accordance with BS 7533-7.

It is important that the laying course material does not become saturated in service. This is normally achieved using an unbound base. However, where a bound base is necessary it should be porous or have drainage provided, e.g. by forming holes to remove water.

Having assessed the site category for the application (Table 1) and the design CBR (Table 4), the designer should use Table 5 to select the thickness for each pavement layer where an unbound base is used or Table 6 to select the thickness of each pavement layer where a non-rigid bound base is used.

The sett size category should be appropriate to the site category and type of base and should be in accordance with Table 5, Table 6 or Table 7.

NOTE The thickness of a sub-base makes no allowance for it to be used as a site access way during construction.

Under adverse weather conditions, or for CBRs of 3% or less, the use of a geotextile separating membrane beneath the sub-base is recommended.

For CBRs of less than 2%, specialist advice should be sought about what would be an appropriate pavement foundation design.

On frost-susceptible soils the total construction thickness should be the minimum recommended for the site location, in cases of doubt a minimum of 450 mm of non frost-susceptible material should be used.

6.4.2 Foundation design – Bound surface course

The foundation design for a bound surface course should be irrespective of paving unit size and type.

The thickness of sub-base and rigid bound base should be selected from Table 7 depending upon site category (see Table 1).

NOTE The thickness of a sub-base makes no allowance for it to be used as a site access way during construction.

Under adverse weather conditions, or for CBRs of 3% or less, a geotextile separating membrane beneath the sub-base is recommended.

For CBRs of less than 2%, specialist advice should be sought on an appropriate pavement foundation design.

On frost-susceptible soils, the total construction thickness should be the minimum recommended for the site location, in cases of doubt a minimum of 450 mm of non frost-susceptible material should be used.

7 Preparation and construction

The subgrade, sub-base and base should be prepared in accordance with BS 7533-7:2010, Clause **5**. The laying course and surface of the pavement should be constructed in accordance with BS 7533-7.

The surface should be constructed in accordance BS 7533-7:2010, Annex A.

8 Overlay design

Where an existing part-worn pavement is to be overlaid, then the design should be undertaken by using the component overlay design method given in BS 7533-1.

Annex A (informative) Worked examples

A.1 Example A

A.1.1 Background

A new development wishes to place small setts in a central square, which is accessible to cars and commercial vehicles for delivery to domestic premises only. The architect is looking for a rough finish and would like an arc pattern.

A site investigation shows that clay soil is present and the testing of samples predicts a foundation CBR of 4%.

A.1.2 Design process

A.1.2.1 Surface selection

The architect prefers setts, size 1 or size 2 (see Table 2).

A.1.2.2 Traffic assessment

The site is to be designated site category III as defined in Table 1. For this site, two equally acceptable design options are available:

a) an unbound surface course design (see **A.1.2.3**); or

b) a bound surface course design (see **A.1.2.4**).

The choice between the two designs may be made on aesthetic grounds, providing that adequate slip/skid resistance and abrasion resistance is demonstrated.

A.1.2.3 Unbound surface course design

A non-rigid unbound base is not appropriate because of the likelihood of commercial vehicles and the low strength of the subgrade (see Table 5).

However, for site category III, Table 6 allows the selection of non-rigid bound base that has a sub-base thickness of 250 mm with 120 mm of bitumen bound or cement bound base. Recommendations and guidance on foundation materials are given in Clause **5**.

For site category III, Table 6 permits the use of setts of size 2 full setts. Therefore, in accordance with the architect's preferences, setts of size 2 are permitted.

A.1.2.4 Bound surface course design

From Table 7, for site category III, the sub-base thickness needs to be 250 mm with 200 mm of bitumen bound or 150 mm of cement bound base. Recommendations and guidance on foundation materials are given in Clause **5**.

For site category III, Table 3 and Table 7 permit the use of a size 2 full setts for this type of base. Therefore, in accordance with the architect's preferences, size 2 full setts with bedding mortar designation Type B together with a design joint compressive strength of 40 N/mm^2 are permitted.

A.1.2.5 Alternative rigid surface design

From Table 7, for site category III, the sub-base thickness needs to be 250 mm with 150 mm of pavement quality concrete base. Recommendations and guidance on foundation materials are given in Clause **5**.

For site category III, Table 3 and Table 7 permit the use of size 1 full setts with bedding mortar designation Type B together with a design joint compressive strength of 40 N/mm^2.

A.2 Example B

A.2.1 Background

An area of stone paving has been proposed as part of a town centre improvement. It will be widely used by buses and delivery vehicles though cars will be excluded for most of the day.

A site investigation was carried out and the foundation CBR was predicted to be 10%.

A.2.2 Design process

A.2.2.1 Surface selection

The designer prefers to use large setts on aesthetic grounds (see Table 2).

A.2.2.2 Traffic assessment

An estimate of the number of commercial vehicles on site is necessary. Therefore, a one day count of the number and type of commercial vehicles was organized. It was estimated, using the conversion factors in Table 8, that there were likely to be more than 60 but less than 200 standard axles per day using any part of the surface of the site.

The site is to be designated site category I as defined in Table 1.

For this site two equally acceptable design options are available (see **6.4**), providing adequate slip/skid resistance and abrasion resistance is demonstrated.

A.2.2.3 Bound surface course design

From Table 7, the sub-base thickness for site category I is 150 mm with 200 mm of bituminous, asphaltic or cement bound material.

In accordance with the designer's preferences, for site category I, Table 3 and Table 7 permit the use of a size 3 full sett with bedding mortar designation Type B or size 4 full sett with bedding mortar designation Type A, together with a design joint compressive strength of 40 N/mm^2.

A.2.2.4 Alternative bound surface course design

From Table 7, the sub-base thickness for site category I is 150 mm with 150 mm of pavement quality concrete base.

In accordance with the designer's preferences, for site category I, Table 3 and Table 7 permit the use of a size 4 shallow sett with bedding mortar designation Type B together with a design joint compressive strength of 40 N/mm^2.

Annex B (informative) Identification of materials and CBR values using a simple field test

Table B.1 provides a method of identification for materials and CBR values using a simple field test.

Table B.1 **Identification of materials and CBR values**

Rock or soil		Simple field test	CBR	Comments
Type	**Condition**		**%**	
Rock	Hard	Requires mechanical pick for excavation	>5	
Sand Gravel	Compact	50 mm, square peg hard to drive in 150 mm	>5	
Clay Sandy clay	Stiff	Cannot be moulded by fingers Need pick for excavation	5–2	
Clay Sandy clay	Firm	Can be moulded by fingers Need spade for excavation	5–2	
Sand Silty clay Clayey sand	Loose	Dry lumps easily broken down 50 mm, square peg driven in easily	2	
Silt Sandy clay Silty clay Clay	Soft	Can easily be moulded by fingers	<2	
Silt Sandy clay Silty Clay Clay	Very soft	Exudes between fingers when squeezed	Refer to specialist advice	

NOTE 1 This Table is based on the principles given in BS 8103-1.

NOTE 2 The CBR of the rock or soil is significantly affected by moisture content.

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