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Incorporating Corrigendum No. 1



BSI Standards Publication

Pavements constructed with clay, concrete or natural stone paving units

Part 101: Code of practice for the structural design of
pavements using modular paving units

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Summary of pages

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Foreword

Publishing information

This part of BS 7533 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 August 2021. 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 committee manager.

Supersession

This part of BS 7533 supersedes [BS 7533-1:2001](#), [BS 7533-2:2001](#), [BS 7533-8:2003](#), [BS 7533-10:2010](#) and [BS 7533-12:2006](#), which are withdrawn. This part of BS 7533 also partially supersedes [BS 7533-6:1999](#) and [BS 7533-7:2010](#).

Relationship with other publications

BS 7533 is published in the following parts:

- Part 101: *Code of practice for the structural design of pavements using modular paving units*;
- Part 102: *Code of practice for the construction and maintenance of pavements using modular paving units¹⁾*; and
- 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

Text introduced or altered by Corrigendum No. 1 is indicated in the text by tags C1 C1. Minor editorial corrections are not tagged.

This is a full revision of the BS 7533 series, in which the principal change is to reduce 12 parts of the series to 3 parts. The following principal changes have been made:

- the combination of information on the structural design of rigid and flexible pavements (now retitled “bound and unbound pavements”), using concrete, clay and stone paving units, from the following parts of the withdrawn series:
 - 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 8: *Guide for the structural design of lightly trafficked pavements of precast concrete flags and natural stone slabs*;
 - Part 10: *Guide for the structural design of trafficked pavements constructed of natural stone setts and bound construction with concrete paving blocks*;
 - Part 12: *Guide to the structural design of trafficked pavements constructed on a bound base using concrete paving flags and natural stone slabs*;
- the removal of repetition between the parts of BS 7533 listed above;
- updating of references and test methods; and,
- clarification and removal of ambiguity and anomalies.

¹⁾ In preparation

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at bsigroup.com/standards, or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

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As a code of practice, this British Standard takes the form of recommendations and guidance. It is not to be quoted as if it were a specification. Users are expected to ensure that claims of compliance are not misleading.

Users may substitute any of the recommendations in this British Standard with practices of equivalent or better outcome. Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

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1 Scope

This British Standard provides recommendations and guidance on the design of pavements surfaced with:

- a) concrete paving blocks produced in accordance with BS EN 1338;
- b) concrete paving flags produced in accordance with BS EN 1339;
- c) natural stone slabs produced in accordance with BS EN 1341;
- d) natural stone setts produced in accordance with BS EN 1342;
- e) clay pavers produced in accordance with BS EN 1344;

constructed in accordance with [BS 7533-3](#), [BS 7533-4](#), [BS 7533-7](#), [BS 7533-9](#)²⁾.

It also provides guidance on the use of:

- 1) concrete kerbs produced in accordance with BS EN 1340; and
- 2) natural stone kerbs produced in accordance with BS EN 1343;

constructed in accordance with [BS 7533-6](#)²⁾.

It applies to areas subject to pedestrian and vehicular loading permissible under The Road Vehicles (Construction and Use) Regulations 1986 [1] with axle loads up to 11 000 kg and a cumulative design traffic of up to 30 million standard axles (msa).

It specifically excludes design traffic above the specified maximum and areas of higher vehicle loading such as aircraft pavements and those in ports and specialized industrial areas.

NOTE 1 Specialist engineering guidance is advised when considering the use of modular paving in applications not covered by this standard.

NOTE 2 Due to historic precedent, it might be preferred to use paving units which are outside the dimensions of the EN standards.

NOTE 3 This standard does not address the specific requirements for applications of tactile paving or other assistance devices. Pedestrian access paving needs to be designed to include appropriate tactile indicators as required by current standards and legislation.

The design of permeable pavements which collect, attenuate and provide a drainage feature are not within the scope of this standard. Refer to [BS 7533-13](#).

Reused materials may be used provided they meet the recommendations of the appropriate clause(s).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions 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.

Standards publications

[BS 1377-4](#), *Methods of test for soils for civil engineering purposes – Part 4: Compaction-related tests*

[BS 7533-3](#), *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*

²⁾ These parts of BS 7533 are expected to be merged into the new BS 7533-102, which is currently in preparation.

[BS 7533-4](#), *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 7533-6](#), *Pavements constructed with clay, natural stone or concrete pavers – Part 6: Code of practice for laying natural stone, precast concrete and clay kerb units*

[BS 7533-7](#), *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 paving blocks*

[BS 7533-9](#), *Pavements constructed with clay, natural stone or concrete pavers – Part 9: Code of practice for the construction of rigid pavements of clay pavers*

[BS 7533-13](#), *Pavements constructed with clay, natural stone or concrete pavers – Part 13: Guide for the design of permeable pavements constructed with concrete paving blocks and flags, natural stone slabs and setts and clay pavers*

[BS 7932](#), *Determination of the unpolished and polished pendulum test value of surfacing units*

BS 8500 (all parts), *Concrete – Complementary British Standard to BS EN 206*

BS 8666:2020, *Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete – Specification*

BS EN 206-1, *Concrete – Part 1: Specification, performance, production and conformity*

BS EN 932-2, *Tests for general properties of aggregates – Part 2: Methods for reducing laboratory samples*

BS EN 933-3, *Tests for geometrical properties of aggregates – Part 3: Determination of particle shape – Flakiness index*

BS EN 1097-1:2011, *Tests for mechanical and physical properties of aggregates – Part 1: Determination of the resistance to wear (micro-Deval)*

BS EN 1097-2, *Tests for mechanical and physical properties of aggregates – Part 2: Methods for the determination of resistance to fragmentation*

BS EN 1338:2003, *Concrete paving blocks – Requirements and test methods*

BS EN 1339, *Concrete paving flags – Requirements and test methods*

BS EN 1340:2003, *Concrete kerb unit – Requirements and test methods*

BS EN 1341, *Slabs of natural stone for external paving – Requirements and test methods*

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

BS EN 1343, *Kerbs of natural stone for external paving – Requirements and test methods*

BS EN 1344:2013, *Clay pavers – Requirements and test methods*

BS EN 12371, *Natural stone test methods – Determination of frost resistance*

BS EN 12372, *Natural stone test methods – Determination of flexural strength under concentrated load*

BS EN 12617-4:2002, *Products and systems for the protection and repair of concrete structures – Test methods – Part 4: Determination of shrinkage and expansion*

BS EN 12620:2002+A1:2008, *Aggregates for concrete*

BS EN 12697-19, *Bituminous mixtures – Test methods – Permeability of specimen*

BS EN 13036-4, *Road and airfield surface characteristics – Test methods – Part 4: Method for measurement of slip/skid resistance of a surface: The Pendulum Test*

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

BS EN 13242, *Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction*

BS EN 13412, *Products and systems for the protection and repair of concrete structures – Test methods – Determination of modulus of elasticity in compression*

BS EN 13755, *Natural stone test methods – Determination of water absorption at atmospheric pressure*

BS EN 13877-1:2013, *Concrete pavements – Part 1: Materials*

BS EN 13877-3³⁾, *Concrete pavements – Part 3: Specifications for dowels to be used in concrete pavements*

BS EN 13892-2, *Methods of test for screed materials – Part 2: Determination of flexural and compressive strength*

BS EN 13892-8, *Methods of test for screed materials – Part 8: Determination of bond strength*

[BS EN 14157:2017](#), *Natural stone test methods – Determination of the abrasion resistance*

BS EN 14227-1:2013, *Hydraulically bound mixtures – Specifications – Part 1: Cement bound granular mixtures*

BS EN 14231, *Natural stone test methods – Determination of the slip resistance by means of the pendulum tester*

PD CEN/TS 12390-9, *Testing hardened concrete – Part 9: Freeze-thaw resistance with de-icing salts – Scaling*

Other publications

[N1] HIGHWAYS ENGLAND. *Manual of contract documents for highway works – Volume 1: Specification for highway works*. London, HMSO⁴⁾

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1 base

one or more layers of material placed above the sub-base that constitutes the main structural element of a pavement on which the laying course is placed

NOTE See [Figure 1](#).

3.1.2 bedding mortar

blend of fine aggregate and cementitious binder with which paving units are installed

3.1.3 bonding mortar

blend of cementitious binder and fine aggregate applied as a liquid slurry to enhance the adhesion bond strength of bedding mortar

3.1.4 bound surface construction

pavement where the paving units are laid on and jointed with cementitious mortar

NOTE This is irrespective of the base material, which may be bound or unbound.

³⁾ This British Standard also informatively references BS EN 13877-2:2004.

⁴⁾ Available at <https://www.standardsforhighways.co.uk/ha/standards/mchw/index.htm>.

3.1.5 capping

layer of material placed on the subgrade to improve or protect the subgrade, onto which the upper foundation layers are placed

NOTE See [Figure 1](#).

3.1.6 cement bound granular material (CBGM)

granular material to which cement has been added

3.1.7 channel

concrete or natural stone unit, used individually or in combination with other units to provide; separation of surfaces at the same level, a physical or visual delineation or containment and separation between areas submitted to different kinds of traffic, a means of collecting and directing surface water

3.1.8 clay paver

paving unit manufactured predominantly from clay or other argillaceous material, with or without any additions, by shaping, drying and firing at a sufficiently high temperature to form a durable product

3.1.9 cobble

natural stone paving unit rounded by erosion, being between 63 mm and 200 mm in diameter

3.1.10 commercial vehicle

vehicle over 3.5 t gross weight

3.1.11 complementary fitting

paving unit, or part of a unit, used to infill an area between different laying patterns or to terminate a laying pattern at a boundary

3.1.12 concrete block

paving unit manufactured from precast concrete that satisfies the following conditions:

- a) at a distance of 50 mm from any edge, any cross-section does not show a horizontal dimension less than 50 mm;
- b) its overall length divided by its thickness is less than or equal to four

NOTE These two conditions are not applicable to complementary fittings.

3.1.13 concrete flag

paving unit manufactured from precast concrete that satisfies the following conditions:

- a) its overall length does not exceed 1 m; and
- b) its overall length divided by its thickness is greater than four

NOTE These two conditions are not applicable to complementary fittings.

3.1.14 design thickness

designed thickness of a pavement layer, excluding permissible manufacturing dimensional tolerances, construction tolerances and regulating to provide surface falls

3.1.15 edge beam

hardened concrete foundation onto which a kerb or channel is bedded using mortar

3.1.16 foundation

lower pavement layers comprising the sub-base and capping (if used) which provide support to the upper pavement layers

NOTE See [Figure 1](#).

3.1.17 geotextile

proprietary fabric that allows water to flow through and reduces migration of particulates between construction layers

3.1.18 joint

area connecting two vertical adjacent units (excluding nibs featured) or between a paving unit and edge restraint

3.1.19 jointing material

material applied to fill a joint which may be structural or non-structural

NOTE See [Figure 1](#) and [Figure 2](#).

3.1.20 kerb

concrete or natural stone unit, individual or in combination with other units, intended to separate surfaces of the same or of different levels, to provide physical or visual delineation or containment and separation between areas submitted to different kinds of traffic

NOTE A line of kerbs may also be referred to as “kerbing”.

3.1.21 laying course

layer of material on which paving units are installed

NOTE See [Figure 1](#).

3.1.22 laying pattern

arrangement of paving units to form specific patterns for either structural requirements or visual effect

3.1.23 modular pavement

pavement having a surface course comprising paving units with joints between them

3.1.24 movement joint

designed break in the pavement structure to allow the pavement to expand, contract or flex

3.1.25 paper break

thin laminar separation between two areas of concrete or bound paving, created by the inclusion of waterproof paper or polythene membrane

3.1.26 pavement

any paved area subject to pedestrian and/or vehicular traffic

3.1.27 paving unit

manufactured or naturally occurring unit used to form the surface course of a modular pavement

NOTE 1 See [Figure 1](#) and [Figure 2](#).

NOTE 2 Paving units may also be referred to as “modules” or “pavers”.

NOTE 3 Kerbs and channels may also be referred to as paving units.

3.1.28 race

fresh concrete foundation into which a kerb or channel is placed

3.1.29 regulating layer

layer of variable thickness applied to an existing surface to adjust the shape preparatory to laying the new surface

NOTE The regulating layer needs to contain aggregate of an appropriate size for the minimum laid thickness and be compatible with the layer below and the new surfacing.

3.1.30 restraint

structural detail that serves to prevent lateral movement of paving units and to prevent loss of the laying course material where applicable

NOTE These may be edge restraint, intermediate or temporary restraint.

3.1.31 sett

paving unit formed from natural stone by cutting or splitting in which the working width does not exceed two times the thickness, and the length does not exceed two times the width

NOTE 1 The minimum working thickness is 40 mm.

NOTE 2 Historically, slender setts at 250 mm or more long with a width of 100 mm and 200 mm or more with a width of 75 mm were used.

3.1.32 slab

paving units formed from natural stone by cutting or splitting in which the width exceeds two times the thickness

3.1.33 structural slab

slab, normally of reinforced concrete, that provides the structural strength of a pavement

3.1.34 slip resistance

concerns the suitability of a pedestrian surface

3.1.35 skid resistance

concerns the suitability of a surface for vehicular use

3.1.36 soldier course

row of pavers or setts laid perpendicular to the general direction of rows

3.1.37 standard axle

axle carrying a load of 8 200 kg

3.1.38 sub-base

layer of material placed above the subgrade or capping (if used) which distributes the loading from the upper pavement layers down to the subgrade

NOTE See [Figure 1](#).

3.1.39 subgrade

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

NOTE See [Figure 1](#).

3.1.40 surface course

layer of paving units that acts as a wearing surface of the pavement

NOTE See [Figure 1](#) and [Figure 2](#).

3.1.41 unbound surface construction

pavement where the paving units are laid on and jointed with selected unbound aggregate, sometimes referred to as flexible surface construction

NOTE This is irrespective of the base material, which may be bound or unbound.

3.2 Abbreviated terms

CBGM	cement bound granular material
CBR	California bearing ratio
DPM	damp-proof membrane
HBM	hydraulically bound material
msa	million standard axles
N/A	not applicable
OGV	other goods vehicle
PPV	Polished Paver Value
PQC	pavement quality concrete
PSV	public service vehicle
PSRV	Polished Slip Resistance Value
USRV	Unpolished Slip Resistance Value

Figure 1 — Pavement layers

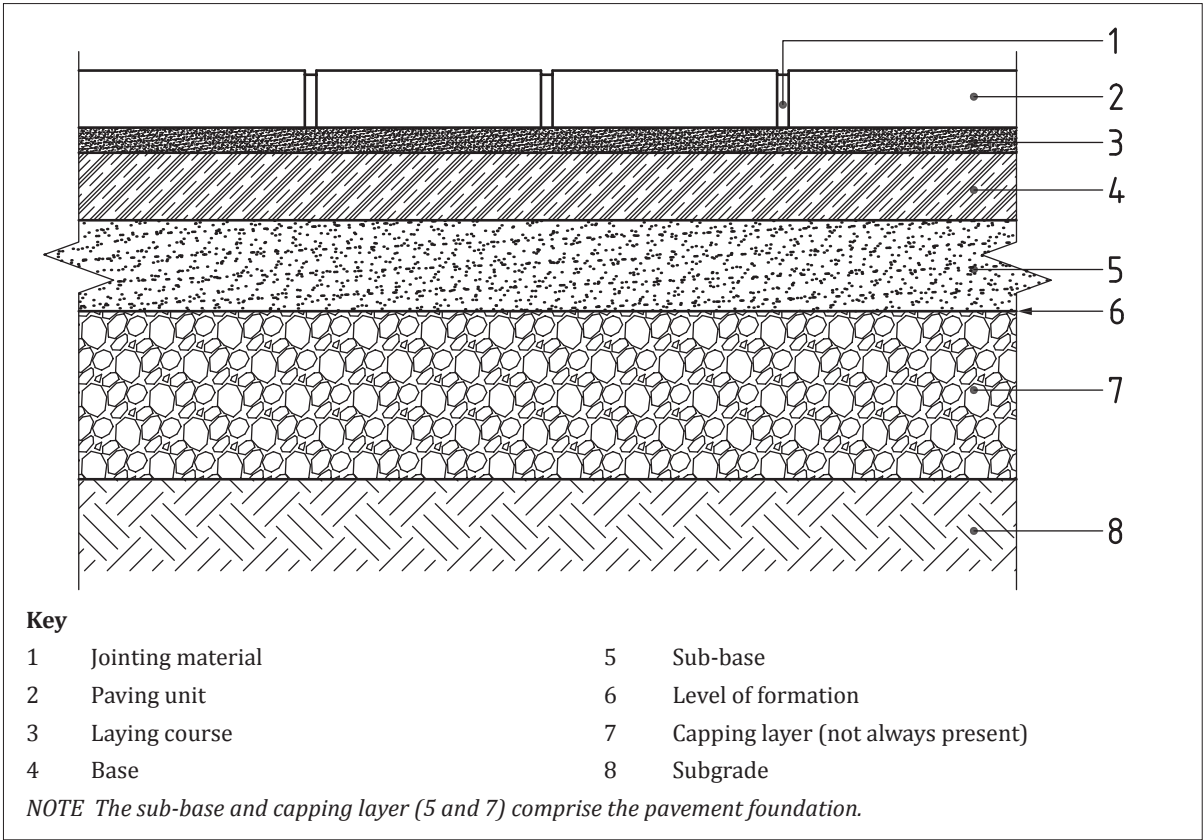
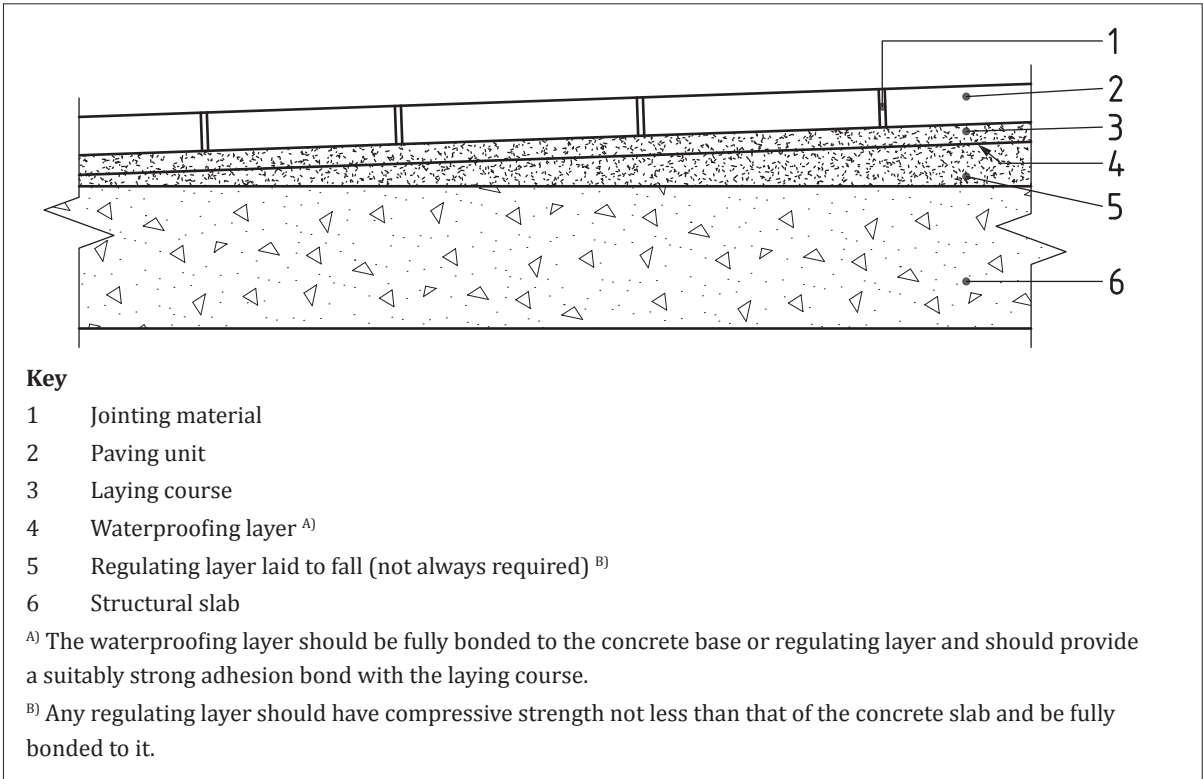


Figure 2 — Pavement layers over a structural slab



4 General design criteria

4.1 Design options

COMMENTARY ON 4.1

Two categories of pavement construction are considered within this standard (see 6.4):

- a) an unbound surface course laid upon a bound or unbound base, and
- b) a bound surface course laid upon a bound or unbound base.

Unbound surface courses typically have a lower installation cost and are simpler to reinstate.

Maintenance of the jointing material might be required to ensure structural integrity. Bound surface courses typically have a higher installation cost and can be more complex to reinstate but might require less maintenance over the life of the pavement.

When determining the preferred construction type, account should be taken of the need to access buried services and the future availability of materials for reinstatement works. Particular consideration should be given to the safety implications of constructing rigid bound layers which require mechanical excavation over shallow or vulnerable buried services.

The preferred surface course material and plan dimensions should be selected and then the designer should undertake a structural design based on the traffic category and subgrade strength. If an acceptable design with the selected surface course is not possible or practicable, an alternative surface course option should be selected, and the design process repeated.

4.2 Evaluation of traffic

4.2.1 Traffic assessment

For unbound surface construction, the traffic category should be selected from [Table 2a](#) based on the cumulative traffic imposed over the design life of the pavement (msa).

For bound surface construction, the traffic category should be selected from [Table 2b](#) based on the number of standard axles per day, i.e. the maximum number expected on a day during the working life.

If a static pressure in excess of 0.8 MPa is to be applied to the paving, a project-specific structural design should be carried out.

If there is no commercial traffic or there is no count available, the traffic category should be selected from the description provided in [Table 2a](#) and [Table 2b](#).

In this situation, if there is dynamic and/or impact loading, the traffic category should be increased to the next level unless the risk can be managed in some other way.

The traffic count should include any anticipated construction traffic and maintenance vehicles such as mechanical sweepers and access platforms.

In a two-way street, the count is of all the traffic in one direction, irrespective of the number of lanes.

If necessary, the traffic count should be modified in accordance with [4.2.2](#).

NOTE 1 The conversion factor for commercial vehicles is provided in [Table 1](#).

NOTE 2 Full methodology is provided in Highways England's Design manual for roads and bridges, CD 224 Traffic assessment [2].

Table 1 — *Standard axles per commercial vehicle*

Vehicle type	Conversion factor	
	Detailed	Consolidated
Buses and coaches	2.6	1.3 (OGV1 + PSV)
2 axle rigid	0.4	
3 axle rigid	2.3	
3 axle articulated	1.7	
4 axle rigid	3.0	3.2 (OGV2)
4 axle articulated	1.7	
5 axle articulated	2.9	
6 axles or more	3.7	
All commercial vehicles (70% OGV2)		2.7

NOTE PSV = public service vehicles (buses and coaches)

OGV = other goods vehicles

Table 2a — *Traffic categories for unbound construction*

Traffic category	Cumulative standard axles (msa)	Road category ^{A)}	Typical applications
9	≤30	1	Adopted highways and commercial/industrial developments used by a high number of commercial vehicles.
8	≤10	2	
7	≤2.5	3	
6	≤0.5	4	Adopted highways and commercial/industrial developments used by a moderate number of commercial vehicles. Pedestrian areas subjected to regular overrun of commercial vehicles. Industrial premises. Petrol station forecourts.
5	≤0.05	N/A	Pedestrian areas subjected to occasional overrun of commercial vehicles. Car parks receiving occasional commercial vehicular traffic.
4	≤0.007	N/A	Urban footways with no planned vehicular overrun. Pedestrian areas used by light commercial vehicles, emergency vehicles and maintenance vehicles.
3	0	N/A	Small car parks subject to car, light van and motorcycle access.
2	0	N/A	Pedestrian and cycle areas, domestic driveways.
1	0	N/A	Pedestrian-only areas, including domestic applications.

^{A)} For road categories, see *Specification for the reinstatement of openings in highways*, Table S1.1 [3].

Table 2b — *Traffic categories for bound construction*

Traffic category	Standard axles per day ^{A)}	Typical applications
9	≤4 000	Adopted highways and commercial/industrial developments used by a high number of commercial vehicles.
8	≤1 400	
7	≤350	
6	≤70	Adopted highways and commercial/industrial developments used by a moderate number of commercial vehicles. Pedestrian areas subjected to regular overrun of commercial vehicles. Industrial premises. Petrol station forecourts.
5	≤7	Pedestrian areas subjected to occasional overrun of commercial vehicles. Car parks receiving occasional commercial vehicular traffic.
4	1	Urban footways with no planned vehicular overrun. ^{B)} Pedestrian areas used by light commercial vehicles, emergency vehicles and maintenance vehicles.
3	0	Small car parks subject to car, light van and motorcycle access.
2	0	Pedestrian and cycle areas, domestic driveways. ^{C)}
1	0	Pedestrian-only areas, including domestic applications.
^{A)} This is based on the short-term loading condition. Due to the nature of bound construction, this may be assumed to satisfy the long-term condition, which is not less than 40 years.		
^{B)} Where a pavement is to be used for occasional events or heavy goods vehicle loading, the pavement should be designed for that loading.		
^{C)} For bound construction, domestic driveways should be designed according to traffic category 3.		

4.2.2 Additional factors

COMMENTARY ON 4.2.2

High horizontal tensile stresses can be introduced into the pavement where dynamic and/or impact loading occurs. Such locations include:

- a) ramps, speed tables and steep gradients (e.g. greater than 8%);*
- b) areas subject to frequent braking and/or turning;*
- c) areas with a design speed greater than 30 mph (50 km/h);*
- d) areas where paving units are laid at a different level to the surrounding pavement, or where vehicles are expected to mount kerbing; and*
- e) areas with channelized traffic, such as bus lanes, tramways, access points and between traffic calming measures.*

Normal lane widths do not generally result in channelized traffic.

In circumstances where one of these additional factors can occur, the design traffic should be multiplied by a factor of two before selecting the traffic category. Where there are two or more additional factors, the design traffic should be multiplied by a factor of three.

4.2.3 Recommended maximum traffic categories for paving unit types

The maximum recommended traffic categories for unbound and bound surface course construction should be in accordance with [Table 3](#).

Table 3 — Recommended maximum traffic categories for paving unit types

Paving unit type	Unbound	Surface construction type		Clause in this document
		Bound system A	Bound system B	
Concrete blocks and clay pavers	9	6	7	6.5
Sawn sided sandstone setts	6	–	–	6.5
		9	9	6.7
Sawn sided stone setts other than sandstone	3	–	–	6.5
		9	9	6.7
Concrete flags and stone slabs	6	4	7	6.6
Cropped sided stone setts	8	9	9	6.7

NOTE Maximum traffic categories for base materials are covered in [Table 21](#) and [Table 26](#).

4.3 Slip/skid resistance for concrete, clay and stone paving units

4.3.1 Slip/skid resistance measurement

COMMENTARY ON 4.3.1

Slip resistance is the property that reduces the risk of pedestrians slipping in wet conditions.

Skid resistance is the property that reduces the risk of vehicles skidding in wet conditions.

In both cases, the higher the value, the less the risk.

Slip and skid resistance is measured using the Pendulum Test. For concrete and clay paving, the Pendulum Test should be carried out in accordance with BS EN 13036-4 to provide the Pendulum Test Value (PTV).

For stone paving, the Pendulum Test should be carried out in accordance with BS EN 14231 to provide the Slip Resistance Value (SRV), most commonly declared as the Unpolished Slip Resistance Value (USRV).

NOTE 1 These values are quoted in the Declaration of Performance for the product.

Paving units can wear and/or polish under the action of vehicle tyres and heavy pedestrian usage. A polishing test in accordance with [BS 7932](#) should be used to evaluate this and a pendulum test should be used to measure the Polished Paver Value (PPV), also known as the Polished Slip Resistance Value (PSRV).

NOTE 2 The PPV test has been designed to give the same numerical values as the Polished Stone Value for aggregates in road surfaces so that published guidance on skid resistance in DMRB CD 236 [4] may be used.

Slip or skid resistance testing should be undertaken using the finish or applied finish to be used in the design.

For stone setts with a cropped surface, for which the PPV test is inapplicable, the same stone should be tested using a mechanically applied finish to a sawn surface.

The slip/skid resistance of tactile paving should be determined using a plane surface paving unit with the same surface material and texture as the tactile product.

4.3.2 USRV and PPV/PSRV values for concrete, clay and stone paving units

Table 4 — Recommended USRV and PPV/PSRV for concrete, clay and stone paving units

Traffic category	USRV (min)	PPV/PSRV (min)
1–3	40	N/A
4 without vehicular traffic ^{A), B)}	40	N/A
4 and 5 ^{A), B)}	45	45
6 and above ^{C)}	50	50

^{A)} Where there is a slope, the minimum USRV should be increased by 1 unit for every 1% of gradient.

^{B)} Unless the units have been ground or polished, it may be assumed that concrete units or clay pavers will meet these requirements.

^{C)} The Highways Authority might require a higher minimum PPV, especially on the approach to junctions, pedestrian crossings, steep slopes or on corners. Guidance is given in DMRB CD 236 [4].

Whilst the PPV test was developed for sites with vehicular traffic, experience has shown that in pedestrian areas with high footfall, some types of natural stone (most commonly, limestone), and some clay pavers can become polished with time. Where this might occur, a PPV test result should satisfy the recommendations in Table 4 for traffic categories 4 and 5 even though there is no vehicular traffic anticipated.

5 Materials

5.1 Foundation materials

Capping material should be Class 6F1, 6F2, 6F3, 6F4 or 6F5 material in accordance with series 0600 of the *Specification for highway works* [N1].

Sub-base material should be Type 1 unbound granular material in accordance with clause 803 of the *Specification for highway works* [N1].

NOTE Alternatively, any of the sub-base materials permitted in the SHW 800 series may be used, except 804 and 805, which may only be used up to and including traffic category 4.

5.2 Base materials

One of the following base materials should be used.

- a) Unbound base material should be Type 1 unbound granular material to clause 803 of the *Specification for Highway Works* [N1].

NOTE 1 Alternatively, any of the base materials permitted in the SHW 800 series may be used, except 804 and 805, which may only be used up to and including traffic category 4.

- b) Bituminous base should be constructed from one or more of the following materials:

- 1) AC 20 dense bin 40/60 des conforming to BS EN 13108-1;
- 2) AC 32 HDM base 40/60 des conforming to BS EN 13108-1;
- 3) AC 20 dense bin 100/150 rec conforming to BS EN 13108-1 traffic category 5 and below;
- 4) AC 20 open bin 100/150 rec conforming to BS EN 13108-1 traffic category 5 and below; and
- 5) AC 32 dense base 100/150 rec conforming to BS EN 13108-1 traffic category 5 and below.

NOTE 2 Proprietary asphalt materials might also be suitable for use as base materials. Porous asphalts might be particularly useful where improved base permeability is sought whilst maintaining structural integrity.

NOTE 3 Some of these materials might not achieve the permeability recommended in 5.4.1.

- c) Cement bound granular material (CBGM) base should be CBGM conforming to BS EN 14227-1:2013, strength class 8/10.
- d) Concrete base should be pavement quality concrete conforming to BS EN 13877-1:2013 with a minimum compressive strength class C32/40 for traffic categories 5 and above, and a minimum compressive strength class of C20/25 for traffic categories 4 and below.

5.3 Laying course materials for unbound surface construction

5.3.1 General

Laying course materials should contain nothing which acts as a binder and/or could detract from the flexible nature of the pavement, e.g. cement, lime, bitumen or resin. The laying course material should be clean, hard and durable, containing no deleterious materials such as wood, plastic or soil.

The laying course material should be free-draining.

NOTE Recycled aggregate may be used as laying course material providing it meets the recommendations of 5.3.

5.3.2 Concrete blocks and flags, clay pavers and sawn sided stone setts in all traffic categories for unbound surface construction

Naturally occurring sand should be selected and graded according to BS EN 12620 or BS EN 13242, GF85 0/4 (MP) fine aggregate, reproduced in Table 5.

Table 5 — Grading of laying course for unbound laying material in all traffic categories

Sieve size mm	Percentage of mass passing %	Maximum change from untreated sample ^{A)}
8	100	–
6.3	95 to 100	–
4	85 to 99	–
0.5	30 to 70	–
0.25	–	+20
0.125	0 to 5	+10
0.063 (fines content)	See Table 6	–

^{A)} See Annex A.

The fines content of the material, i.e. the percentage of material passing a 0.063 mm sieve, is determined by the laying course material category. The fines content for specific laying course material categories should be not greater than the values given in Table 6.

NOTE For sand with a fines content below f_3 , the supplier of the sand needs to be aware of the additional parameter in Table 6.

Table 6 — Fines content of unbound laying course material

Traffic category	Laying course material category	Maximum percentage by mass passing 0.063 mm	BS EN 12620:2002+A1:2008 fines content category
7, 8, 9, 10	I	1.0 ^{A)}	$f_{1.0}$
6	II	1.5	$f_{1.5}$
5	III	3	f_3
1, 2, 3, 4	IV	4	f_4

^{A)} See Annex A.

5.3.3 Natural stone slabs in all traffic categories and cropped natural stone setts in traffic categories 1 to 4 for unbound surface construction

The laying course material for paving with natural stone slabs in all traffic categories and natural stone setts in traffic categories 1 to 4 should be crushed igneous rock graded in accordance with [Table 7](#) and should be produced in accordance with either BS EN 12620 or BS EN 13242, G_c85 0/4:

- a) with a flakiness index of less than FI₃₅ when measured in accordance with BS EN 933-3; and
- b) with resistance to impact conforming to BS EN 12620 or BS EN 13242, category SZ₁₈, determined in accordance with BS EN 1097-2.

Table 7 — Grading for unbound laying course material for natural stone slabs in all traffic categories and cropped natural stone setts in traffic categories 1 to 4

Sieve size	Percentage of mass passing
mm	%
8	100
2	35 to 60
1	17 to 42
0.5	8 to 35
0.125	5 to 10
0.063 (fines content)	2 to 9

5.3.4 Cropped natural stone setts in traffic categories 5 to 9 for unbound surface construction

The laying course material for cropped stone setts should be crushed igneous rock graded in accordance with [Table 8](#) and should be produced in accordance with either BS EN 12620 or BS EN 13242, G_c85 2/6:

- a) with a flakiness index of less than FI₂₀ when measured in accordance with BS EN 933-3; and
- b) with resistance to impact category not greater than SZ₁₈ or LA₂₀ determined in accordance with BS EN 1097-2.

Table 8 — Grading for unbound laying course material for cropped natural stone setts in traffic categories 5 to 9

Sieve size	Percentage of mass passing
mm	%
8	100
6.3	85 to 99
2	0 to 20
1	0 to 5
0.063 (fines content)	0 to 2

Only if heavy vibratory compaction equipment cannot be used during installation, the laying course material should be locally substituted with the materials described in [5.3.3](#).

The designer should make allowance in the base materials for moisture content dissipation (see [6.2](#) for recommendations on the sub-base).

5.4 Laying course materials for bound surface construction

5.4.1 Proprietary bedding mortar

Proprietary bedding mortar should be produced in accordance with the characteristics given in [Table 9](#).

NOTE 1 Bedding mortar complying with [Table 9](#) may be assumed to be non-frost susceptible.

In selecting the bedding and base materials, it should be assumed that surface and/or ground water will enter the laying course. The volume will vary depending on circumstances but the potential impact on the construction should be taken into account at the design stage. Both permeability and capillarity should be taken into account. When measured in accordance with BS EN 12697-19 and provided that the base is permeable (as defined in [Annex B](#), that is $\geq 1 \times 10^{-4}$ m/s) then vertical permeability should be $\geq 5 \times 10^{-5}$ m/s.

When the base is not sufficiently permeable then the bedding mortar should be sufficiently permeable for water to enter the secondary drainage. In this case, a horizontal permeability of $\geq 5 \times 10^{-5}$ m/s should be specified.

NOTE 2 Further guidance on management of moisture can be found in [6.10](#).

If the base is less permeable than $\geq 1 \times 10^{-4}$ m/s and the permeability of the bedding is less than that of the base then the capillarity of the bedding mortar should be determined in order to demonstrate that there will not be an unacceptable risk to the performance of the surface course.

NOTE 3 Capillarity may be determined in accordance with [Annex C](#), with a maximum rise of 20 mm.

Table 9 — Bedding mortar characteristics

Characteristic	Performance	
	Type 25 bedding mortar	Type 35 bedding mortar
Compressive strength ^{A)}	≥ 25 MPa	≥ 35 MPa
Flexural strength ^{A)}	≥ 3.5 MPa	≥ 4.5 MPa
Modulus of elasticity ^{B)}	(15 000 $\pm$ 3 500) MPa	(18 000 $\pm$ 3 500) MPa
Shrinkage ^{C)}	$\leq 0.09\%$	$\leq 0.09\%$
Permeability ^{D)}	$\geq 5 \times 10^{-5}$ m/s	$\geq 5 \times 10^{-5}$ m/s

^{A)} Measured in accordance with BS EN 13892-2 after 28 days.

^{B)} Measured in accordance with BS EN 13412 after 28 days.

^{C)} Measured in accordance with BS EN 12617-4:2002, Clause 6 after 56 days with curing in accordance with BS EN 12617-4:2002, **A.1.2**.

^{D)} Measured in accordance with BS EN 12697-19.

NOTE 1 In all situations, Type 25 mortar may be replaced with Type 35 mortar.

NOTE 2 Tests in BS EN 13892-2 for compressive and flexural strength and BS EN 13412 for modulus of elasticity need to be made concurrently in the same testing facility, which has UKAS accreditation or equivalent for one or more of the tests.

NOTE 3 Factory production control testing may be carried out in the producer's own laboratory.

5.4.2 Bonding mortar for bound surface construction

Bonding mortar is necessary in Bound system B. It is a blend of cementitious binder and fine aggregate; it should not contain chemical admixtures which could specifically reduce the water permeability of the cured bonding layer.

NOTE It is applied as a liquid slurry having a thick creamy consistency.

When measured in combination with the bedding mortar, bonding mortar should be applied to the base and underside of the paving element in order to provide an adhesion bond strength of ≥ 2.0 MPa; this is from the base to the bedding mortar and paving element to bedding mortar when measured in accordance with BS EN 13892-8 after 28 days.

5.4.3 Site-batched non-proprietary bedding mortar for bound surface construction

For traffic categories 1 to 4, site-batched non-proprietary mortars may be used.

NOTE Typically a mortar comprising 1:4 Portland cement-aggregate (proportions by volume) is used.

The aggregate used in the bedding mortar should be in accordance with [Table 10](#).

Table 10 — Recommended aggregate properties for site-batched non-proprietary bedding mortar

Properties	Category to BS 12620
Grading	2/6 (preferred) or 1/4 or 2/8, G _c 85/20
Minimum % crushed fines	C _{70/10}
Maximum fines content	f ₄
Shape – flakiness index	Fl ₂₀
Resistance to fragmentation	SZ ₂₆ or LA ₃₀
Acid-soluble sulfate content	AS _{0.2}
Total sulfur	S ₁
Durability against freeze-thaw	F ₁

Recycled materials with constituents which alter the rate of setting and hardening of hydraulically bound mixtures should not be used.

5.5 Jointing materials for unbound surface construction

5.5.1 General

The joint filling material in unbound pavements should contain no material which acts as a binder and could detract from the flexible nature of the pavement, e.g. cement or lime. The material should be clean, hard and durable, containing no undesirable leachates.

NOTE Angular shaped particles perform better than rounded particles in unbound pavements.

5.5.2 Concrete, clay and sawn sided paving units for unbound surface construction

The jointing material for concrete, clay and sawn sided stone paving units should be dried free-flowing silica aggregate, the grading of which is given in [Table 11](#) and conforms to a BS EN 12620 G_F 85 0/1 (FP) F4 fine aggregate.

Table 11 — Grading for jointing material for concrete, clay and sawn sided stone paving units

Sieve size	Percentage of mass passing
mm	%
2	100
1	85 to 99
0.5	55 to 100
0.063 (fines content)	0 to 2

5.5.3 Cropped/cleft stone paving units for unbound surface construction

NOTE Joints may be filled using the bedding material if it flows freely into the open joint.

Aggregate used to fill joints should be crushed igneous rock with grading in accordance with [Table 7](#). Where it is necessary to have a finer material in order to fill the joints, the grading should be determined using formulae 1 and 2:

$$\frac{D_{15}}{d_{85}} < 4 \quad (1)$$

where:

- D* sieve size of laying course material at which 15% passes;
- d* sieve size of joint filling material at which 85% passes

and

$$\frac{D_{50}}{d_{50}} < 10 \quad (2)$$

where:

- D sieve size of laying course material at which 50% passes;
 d sieve size of joint filling material at which 50% passes

Fine topping material should be crushed igneous rock or carboniferous limestone, specified as 1 mm to dust, with not less than 45% passing the 0.063 mm sieve.

5.6 Jointing materials for bound surface construction

5.6.1 Slurry grout jointing mortar

The maximum aggregate particle size should be not greater than 40% of the joint width.

The material used for jointing should be a cementitious slurry grout conforming to [Table 12](#).

Table 12 — *Jointing mortar characteristics*

Characteristic	Performance	
	Type 25 jointing mortar	Type 40 jointing mortar
Compressive strength ^{A)}	≥25 MPa	≥40 MPa
Flexural strength ^{A)}	≥3.5 MPa	≥6 MPa
Modulus of elasticity ^{B)}	(18 000 ±4 000) MPa	(20 000 ±4 000) MPa
Shrinkage ^{C)}	≤0.15%	≤0.15%
Adhesive strength ^{D)}	≥1.0 MPa	≥1.5 MPa
Frost/salt resistance class ^{E)}	≤1 500g/m ²	≤1 500g/m ²

^{A)} Measured in accordance with BS EN 13892-2 after 28 days.

^{B)} Measured in accordance with BS EN 13412 after 28 days.

^{C)} Measured in accordance with BS EN 12617-4:2002, Clause 6 after 56 days with curing in accordance with BS EN 12617-4:2002, A.1.2.

^{D)} Measured in accordance with BS EN 13892-8 after 28 days.

^{E)} Measured in accordance with [CEN/TS 12390-9](#) after 28 cycles (CDF Test)

NOTE 1 All tests, apart from the frost salt resistance class test, needs to be made concurrently in the same testing facility, which has UKAS accreditation or equivalent for one or more of the tests.

NOTE 2 Factory production control testing may be carried out in the producer's own laboratory.

5.6.2 Site-batched non-proprietary jointing mortar for bound surface construction

For traffic categories 4 and below, site-batched non-proprietary jointing mortar may be used.

NOTE Typically, a mortar comprising 1:3 Portland cement-aggregate mortar (proportions by volume), using fine aggregate conforming to BS EN 12620, GF85 0/1 (MP) is used.

5.7 Paving units

COMMENTARY ON 5.7

In addition to meeting the mandatory requirements of the relevant product standards, it is recommended that certain dimensional limitations and performance requirements are also adhered to when designing a modular pavement to ensure durability and performance in use.

The light reflection value (LRV) of paving units and contrast between adjacent paving units can be important when considering access by blind and partially sighted people, particularly around steps, ramps and road crossings. Guidance on LRV is contained within [BS 8300](#).

5.7.1 Concrete blocks

5.7.1.1 General

Concrete blocks should be produced in accordance with BS EN 1338.

Unlike stone setts, dimensions should be stated as Length (L) × Width (W) × Thickness (D), e.g. 200 mm (L) × 100 mm (W) × 65 mm (D).

NOTE In this context, “D” refers to the thickness of the block.

5.7.1.2 Weathering resistance

In areas subject to regular treatment with de-icing salts the weathering resistance should be Class 3 in accordance with BS EN 1338:2003, Table 4.2.

In areas subject to freeze/thaw without regular treatment with de-icing salts, the minimum weathering resistance should be Class 2 in accordance with BS EN 1338:2003, Table 4.1.

In areas not subject to freeze/thaw, the minimum weathering resistance should be Class 1 in accordance with BS EN 1338:2003, Table 4.1.

5.7.1.3 Abrasion resistance

In areas subject to intensive pedestrian and vehicular traffic, the abrasion resistance should be Class 4 in accordance with BS EN 1338:2003, Table 5.

In areas subject to normal pedestrian and vehicle use (e.g. public footpaths and roads) the minimum abrasion resistance should be Class 3 in accordance with BS EN 1338:2003, Table 5.

In areas subject to light pedestrian and vehicular use (e.g. gardens, drives) the minimum abrasion resistance should be Class 1 in accordance with BS EN 1338:2003, Table 5.

NOTE Intensive pedestrian traffic refers to areas expected to receive over 500 million pedestrians in the life of the pavement. Examples would be busy commuter stations, airports and large shopping malls. Intensive vehicular traffic refers to traffic categories 7–9 in [Table 2a](#) and [Table 2b](#).

5.7.1.4 Slip/Skid resistance

Slip/skid resistance should be in accordance with [4.3](#).

5.7.2 Concrete flags

5.7.2.1 General

Concrete flags should be produced in accordance with BS EN 1339.

NOTE The characteristic bending strength is used in the design of the pavement surface course. See [6.6](#).

Unlike stone slabs, dimensions should be stated as Length (L) × Width (W) × Thickness (D), e.g. 450 mm (L) × 300 mm (W) × 65 mm (D).

NOTE In this context, “D” refers to the thickness of the flag.

5.7.2.2 Weathering resistance

In areas subject to regular treatment with de-icing salts the weathering resistance should be Class 3 in accordance with BS EN 1339:2003, Table 4.2.

In areas subject to freeze/thaw without regular treatment with de-icing salts, the minimum weathering resistance should be Class 2 in accordance with BS EN 1339:2003, Table 4.1.

In areas not subject to freeze/thaw, the minimum weathering resistance should be Class 1 in accordance with BS EN 1339:2003, Table 4.1.

5.7.2.3 Abrasion resistance

In areas subject to intensive pedestrian and vehicular traffic, the abrasion resistance should be Class 4 in accordance with BS EN 1339:2003, Table 6.

In areas subject to normal pedestrian and vehicle use (e.g. public footpaths and roads) the minimum abrasion resistance should be Class 3 in accordance with BS EN 1339:2003, Table 6.

In areas subject to light pedestrian and vehicular use (e.g. gardens, drives) the minimum abrasion resistance should be Class 1 in accordance with BS EN 1339:2003, Table 6.

NOTE Intensive pedestrian traffic refers to areas expected to receive over 500 million pedestrians in the life of the pavement. Examples would be busy commuter stations, airports and large shopping malls. Intensive vehicular traffic refers to traffic categories 7–9 in [Table 2a](#) and [Table 2b](#).

5.7.2.4 Slip/Skid resistance

Slip/skid resistance should be in accordance with [4.3](#).

5.7.3 Clay pavers

5.7.3.1 General

Clay pavers should be produced in accordance with BS EN 1344.

NOTE 1 Although BS EN 1344 does not place limitations on dimensions, clay pavers are typically produced in small sizes for use in traditional laying patterns.

NOTE 2 The declared transverse breaking load is used in the design of the pavement surface course. See [6.5](#).

5.7.3.2 Weathering resistance

In areas subject to freeze/thaw, the minimum weathering resistance should be Class FP100 in accordance with BS EN 1344:2013, Table 2.

In areas not subject to freeze/thaw, the minimum weathering resistance should be Class FP0 in accordance with BS EN 1344:2013, Table 2.

5.7.3.3 Abrasion resistance

In areas subject to intensive pedestrian and vehicular traffic, the abrasion resistance should be Class A3 in accordance with BS EN 1344:2013, Table 4.

In areas subject to normal pedestrian and vehicle use (e.g. public footpaths and roads) the minimum abrasion resistance should be Class A2 in accordance with BS EN 1344:2013, Table 4.

In areas subject to light pedestrian and vehicular use (e.g. gardens, drives) the minimum abrasion resistance should be Class A1 in accordance with BS EN 1344:2013, Table 4.

NOTE Intensive pedestrian traffic refers to areas expected to receive over 500 million pedestrians in the life of the pavement. Examples would be busy commuter stations, airports and large shopping malls. Intensive vehicular traffic refers to traffic categories 7–9 in [Table 2a](#) and [Table 2b](#).

5.7.3.4 Slip/Skid resistance

Slip/skid resistance should be in accordance with [4.3](#).

5.7.4 Natural stone setts and slabs

NOTE Further commentary on natural stone properties is provided in [Annex D](#).