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BRITISH STANDARD

BS 7533-8:2003

Pavements constructed with clay, natural stone, or concrete pavers —

Part 8: Guide for the structural design of lightly trafficked pavements of precast concrete flags and natural stone flags

ICS 93.080.20

Confirmed
November 2008

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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.

Concrete Society

County Surveyors' Society

Department of the Environment, Transport and the Regions (Highways Agency)

Institution of Civil Engineers

Interlay (Association of Block Paving)

Interpave (Concrete Block Paving Association)

Landscape Institute

Society of Chemical Industry

Stone Federation

Transport Research Laboratory

The following organizations were also represented in the drafting of the standard, through subcommittees B/507/1 and B/507/2:

British Slate Association

British Civil Engineering Manufacturers' Association

Department of the Environment, Transport and the Regions (Building Research Establishment)

Ministry of Defence

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Foreword

This part of BS 7533 has been prepared by Technical Committee B/507.

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 than 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: 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.*

NOTE This part of BS 7533 is based largely on research work commissioned by Interpave, the precast concrete paving and kerb association.

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 does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 10, an inside back cover and a back cover.

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1) In preparation.

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1 Scope

This British Standard gives guidance on the design of flexible pavements surfaced with precast concrete flags or natural stone slabs and laid on a 30 mm sand laying course with sand filled narrow joints, in accordance with BS 7533-4. It applies to pavements subject to occasional overrun by no more than 15 commercial vehicles per day at speeds not exceeding 50 kph (30 mph).

The fundamental objective is the assessment of the thickness of base material to be used beneath precast concrete flags and natural stone slabs to ensure that the allowable stresses in the paving units and the subgrade are not exceeded.

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 6100-2.4.1:1992, *Glossary of building and civil engineering terms — Part 2: Civil engineering — Section 4.1: Highway, railway and airport engineering — Highway engineering.*

BS 7263-1:2001, *Precast concrete flags, kerbs, channels, edgings and quadrants — Part 1: Precast, unreinforced concrete paving flags and complementary fittings — Requirements and test methods.*

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 7533-4:1998, *Pavements constructed with clay, natural stone or concrete pavers — Code of practice for the construction of pavements of precast concrete flags or natural stone slabs.*

BS EN 1341:2000, *Slabs of natural stone for external paving — Requirements and test methods.*

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

3 Terms and definitions

For the purposes of this part of BS 7533 the terms and definitions given in BS 6100-2.4.1:1992 and the following apply.

3.1
paving unit
precast concrete flag of designation E, F or G, conforming to BS 7263-1:2001 (excluding 50 mm thick), with a class B2 bending stress; or a natural stone flag of square plan, not exceeding 450 mm × 450 mm, conforming to BS EN 1341:2000 with a class 5 breaking load

3.2
laying course
layer of material on which paving units are bedded

3.3
subgrade
upper part of the soil, natural or constructed, that supports the loads transmitted by the overlying pavement

3.4
pavement
any paved area subject to pedestrian and/or vehicular traffic

3.5
base material
layer of material, either Type 1 or Type 2 granular material or cement bound material, as specified in the Specification for Highway Works (see Clause **2**), placed immediately above the subgrade

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3.6
cement bound material (CBM)
granular material to which cement has been added

3.7
standard axle
axle carrying a load of 8 200 kg

3.8
cumulative traffic
number of standard axles a pavement is designed to carry over its lifetime

3.9
commercial vehicle
vehicle having an unladen weight exceeding 1.5 t

4 Materials

Precast concrete flags should conform to BS 7263-1. Natural stone slabs should conform to BS EN 1341.

NOTE Marble slabs are unsuitable for external trafficked pavements in the U.K.

5 General design

The design of the pavement should be based on the following assumptions regarding the construction.

a) The construction generally conforms to BS 7533-4.

b) The minimum thickness of any base material is 100 mm.

c) The laying course sand conforms to BS 7533-4:1998, **6.9.1**.

d) The joints are filled with sand conforming to BS 7533-4:1998, **6.9.1**.

Sedimentary stones should be laid on their bedding plane, where this is apparent.

6 Design

NOTE See Annex A for an example of design.

6.1 Subgrade assessment

If laboratory CBR values are not available then Table 1 may be used as a guide to the equilibrium CBR values.

Table 1 — Estimated equilibrium CBR values for design

Type of soil	Plasticity index	Estimated CBR %
Heavy clay	70	2
	60	2
	50	2
	40	3
Silty clay	30	4
Sandy clay	20	5
	10	5
Sand poorly graded	—	20
Sand well graded	—	40
Sandy gravel	—	60

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6.2 Evaluation of traffic

Firstly the total number of commercial vehicles using an area during the design life of the pavement should be obtained. In the absence of more reliable information, an estimate may be made based on Table 2.

Table 2 — Number of commercial vehicles

Location	Commercial vehicles per day
Residential areas	1
Small shopping areas	5
Large shopping areas	10
Precincts and pedestrianized areas	15

For pavements subject to normal vehicle loads, it may be assumed that each commercial vehicle per day is equivalent to one standard axle per day. Otherwise, where the actual traffic mix is known, Table 3 should be used to determine the standard axles per day.

Table 3 — Standard axle conversion

Vehicle type	Number of standard axles per commercial vehicle
2 axle rigid	0.34
3 axle rigid	1.70
4 axle	2.60

6.3 Determination of construction thickness

NOTE For overlay pavements see Annex B.

The following information should be obtained for design.

a) The type and number of commercial vehicles per day.

b) The required design life

NOTE 20 years is commonly used.

c) The type of base.

d) The paving unit size and thickness.

6.4 Design procedure

6.4.1 *General*

It is essential that the required thickness of the base is determined by the use of the graphs in Figure 1, Figure 2 and Figure 3, to prevent overstressing of the paving unit or the subgrade. The thicker of the two values should be adopted.

6.4.2 *Paving unit stress limiting method*

To determine the base thickness required to prevent overstressing of the paving unit, the cumulative standard axles determined in **6.2** should be plotted on the "number of standard axles" axis on Figure 1. A vertical line should then be projected upwards to intersect the selected base material curve and a horizontal line projected from this intersection to cut the "base thickness axis".

6.4.3 *Subgrade stress limiting method*

To determine the base thickness required to prevent overstressing of the subgrade, the cumulative standard axles determined in **6.2** should be plotted on the "number of standard axles" axis on Figure 2 or Figure 3 as appropriate. A vertical line should then be projected upwards to intersect the base CBR curve and a horizontal line projected from this intersection to cut the "base type axis", and then vertically downward to indicate the required base thickness.

6.4.4 *Base thickness*

The thicker of the two base thicknesses evaluated in **6.4.2** and **6.4.3** should be adopted for the design.

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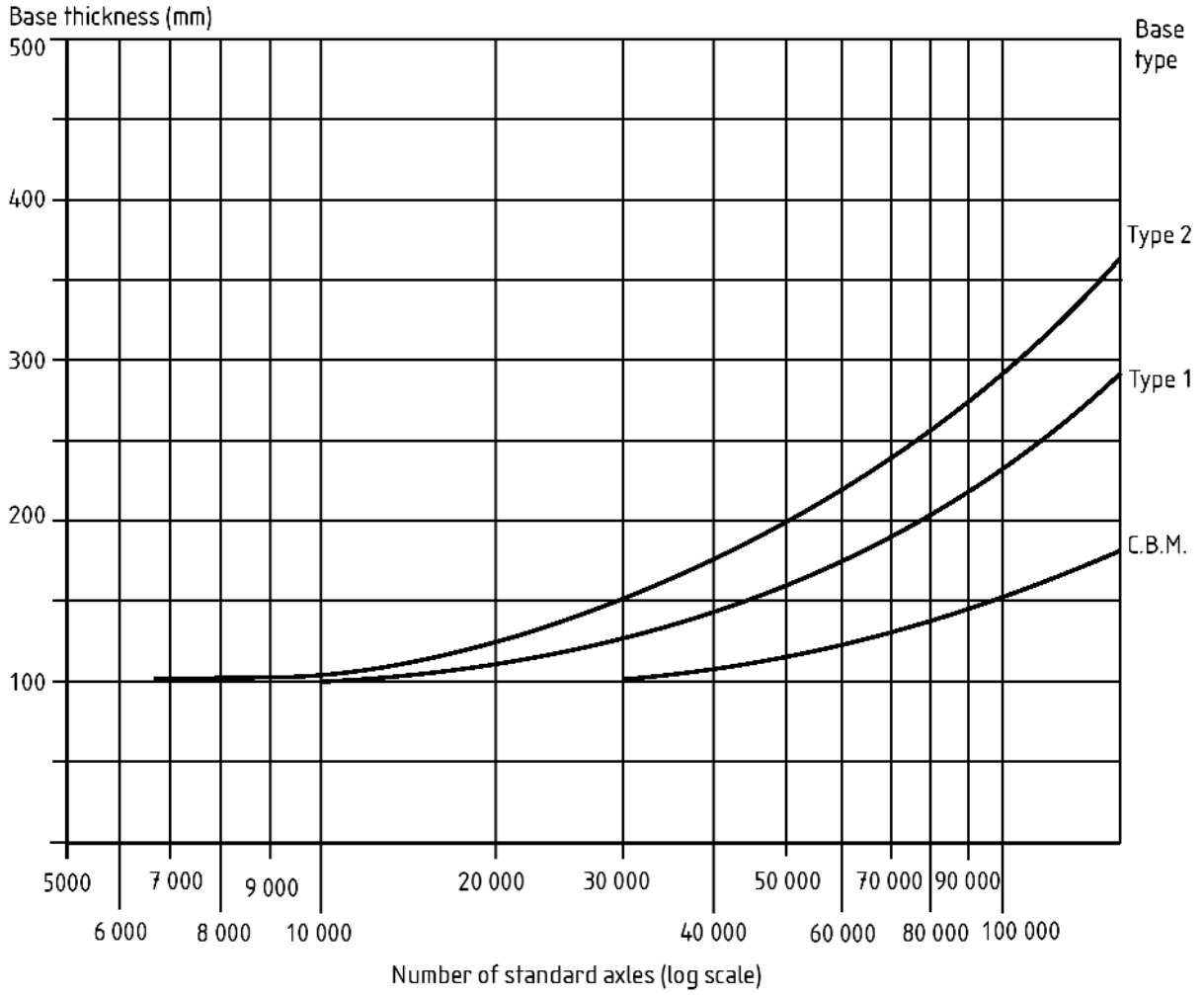

Figure 1 — Graph: base design for paving flag overstressing

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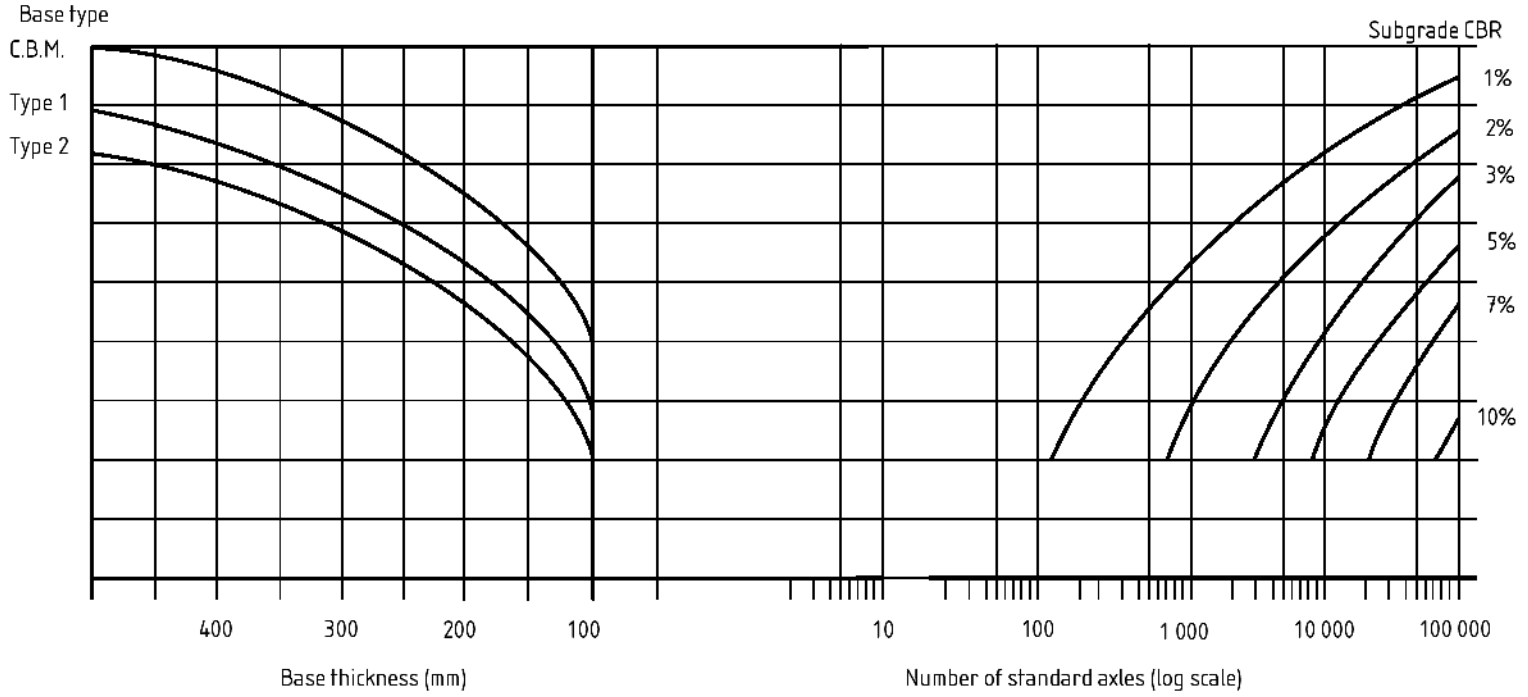

Figure 2 — Graph: base design for subgrade overstressing (400 mm × 400 mm and 450 mm × 450 mm paving units)

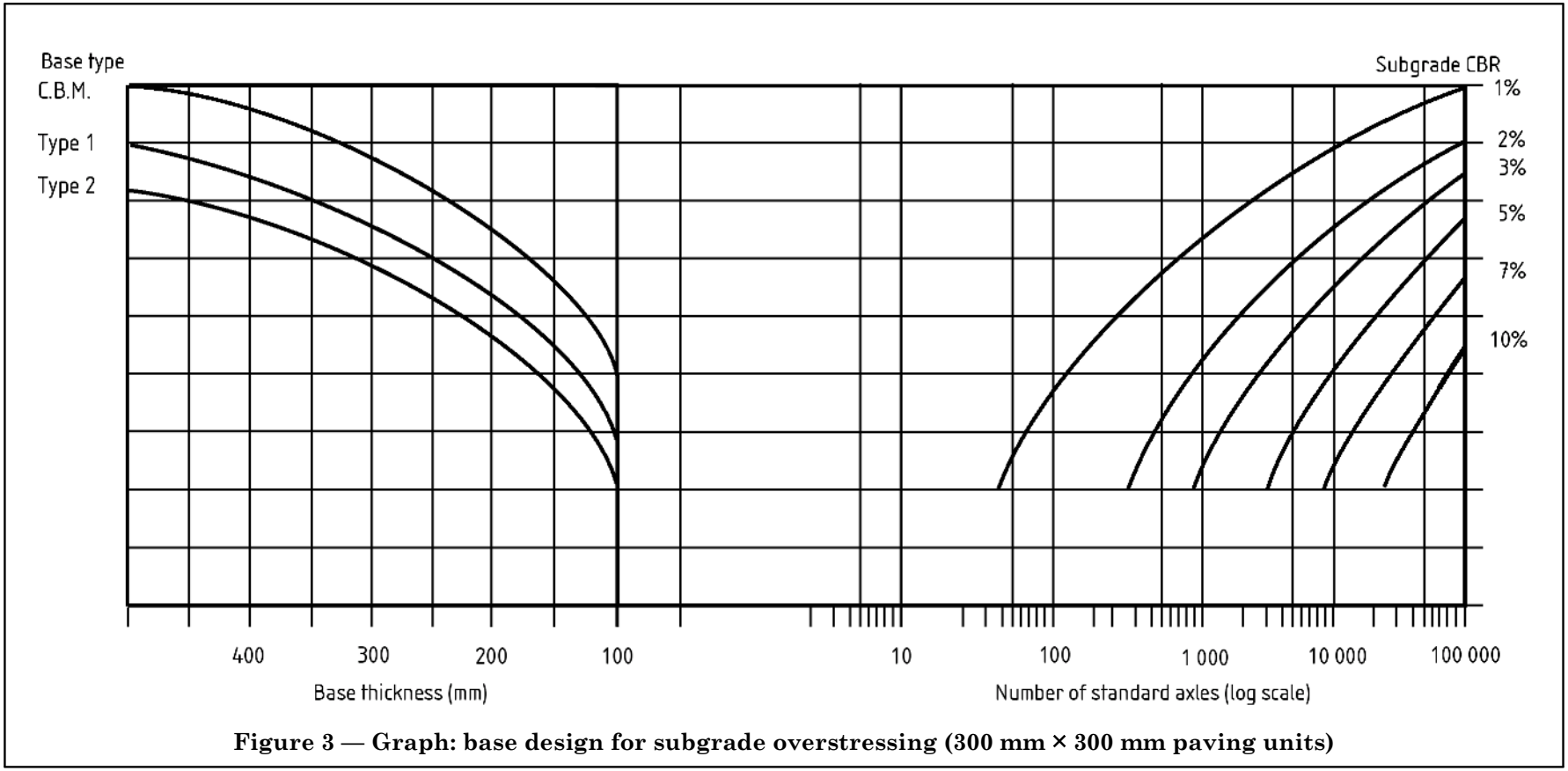

Figure 3 — Graph: base design for subgrade overstressing (300 mm × 300 mm paving units)

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Annex A (informative)
Design example

A pavement in a shopping centre is to be constructed using 400 mm × 400 mm × 65 mm paving units. It is estimated that five days per week there will be 10 commercial vehicles per day servicing the shops. It is anticipated that this daily traffic will comprise six number 2-axle rigid, three number 3-axle rigid, and one number 4-axle, vehicles. Servicing will take place 50 weeks a year over a 20 year design life. A site investigation indicates the CBR of the subgrade is 3 % and the base material to be used is Type 1.

a) The conversion factors in Table 3 can be used to determine the number of standard axles:

6 number 2-axle rigid at 0.34	= 2.04
3 number 3-axle rigid at 1.70	= 5.10
1 number 4-axle vehicle at 2.60	= 2.60
	= 9.74

b) The total number of standard axles in the 20 year design life:

= 5 × 50 × 20 × 9.74	= 48 700
	Say 50 000

c) From the graph of Figure A.1:

Base thickness = 165 mm Type 1

d) From the graph of Figure A.2:

Base thickness = 240 mm Type 1

e) The greater thickness from steps c) and d) is adopted for design purposes, i.e.:

Required thickness of Type 1 = 240 mm

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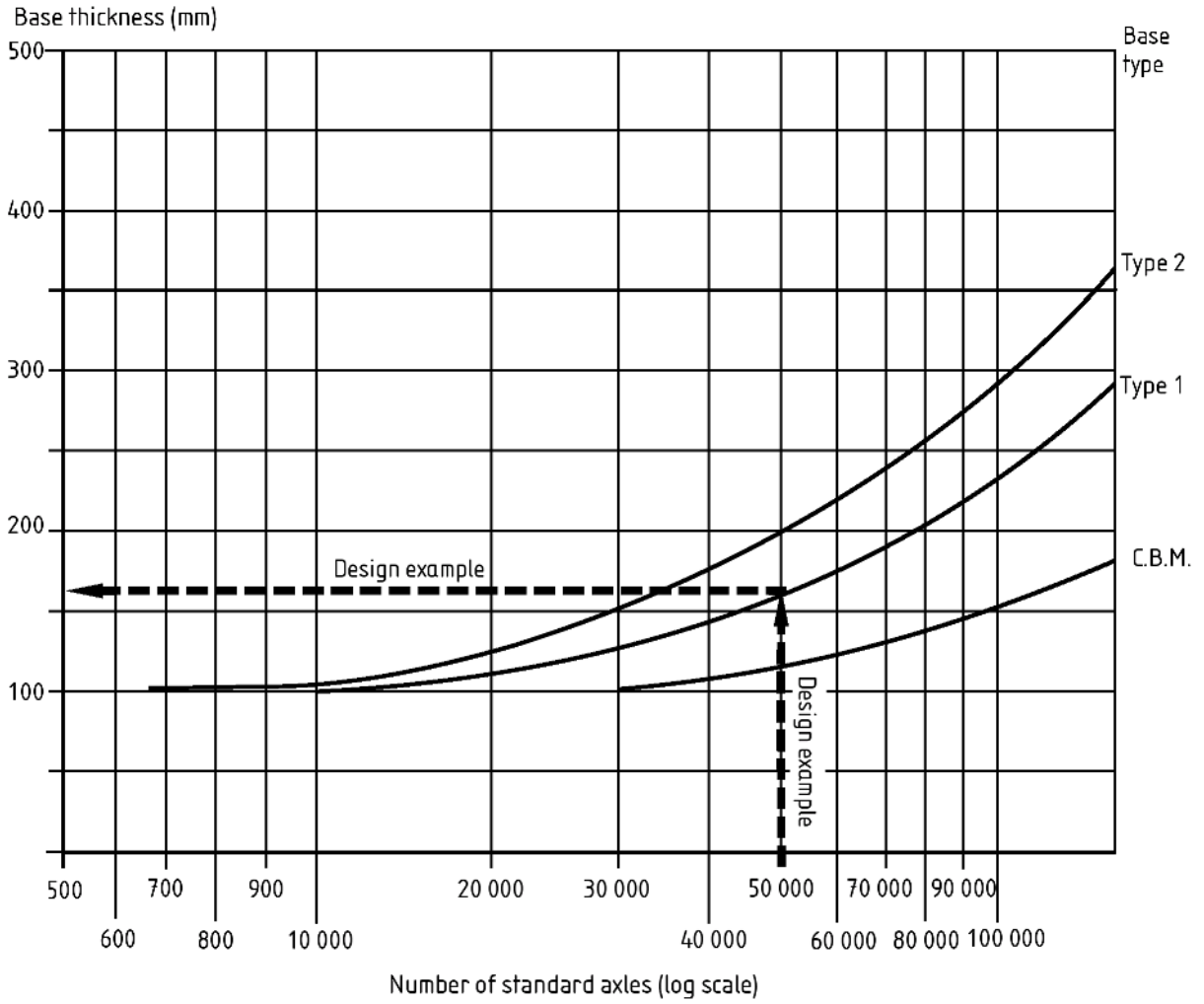

Figure A.1 — Graph: base design for paving flag overstressing — Design example

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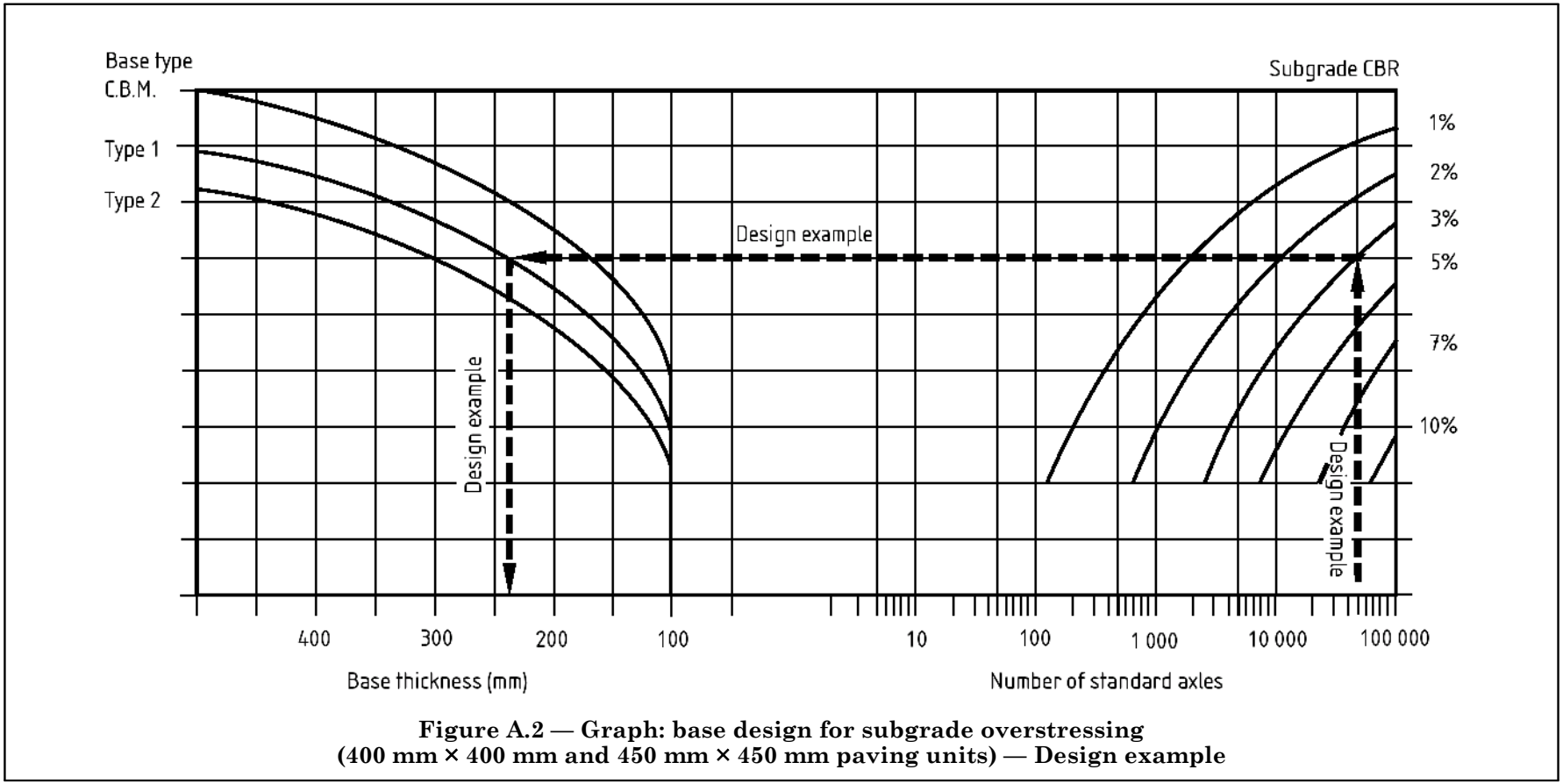

Figure A.2 — Graph: base design for subgrade overstressing (400 mm × 400 mm and 450 mm × 450 mm paving units) — Design example

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Annex B (normative)
Overlay pavements

In pedestrian schemes, paving units are often used as an overlay to existing bituminous pavements. If vehicles are to use the area, then it is first necessary to estimate the residual life of the existing pavement to determine the overlay depth needed to give the required design life.

The existing pavement should be inspected for surface cracking and rutting and an assessment on the residual life should be made. By using one or both of the factors given in Table B.1 and Table B.2, the equivalent thickness can be calculated.

Table B.1 — Condition Factor CF1

Condition of material	CF1
As new	1.0
Some cracking	0.8
Substantial cracking	0.5
Fully cracked, crazed and spalling	0.2

Table B.2 — Condition Factor CF2

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

The existing construction thickness should be multiplied by the Condition Factors CF1 and CF2, where applicable. This equivalence value should then be compared with the base design thickness, excluding flag and laying course, obtained by the design method given in this standard.

If the base design thickness exceeds the equivalence value of the existing pavement then the new design is adequate.

If the base design thickness is less than the equivalence value of the existing pavement then the base thickness should be increased.

Where the new base material is different from the existing base material both base thicknesses should be converted to an equivalent thickness of DBM (dense bitumen macadam), using the procedure outlined in BS 7533-1.

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