

Code of practice for slating and tiling (including shingles)

ICS 91.060.20

Committees responsible for this British Standard

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Association of Building Component Manufacturers
Association of Building Engineers
British Precast Concrete Federation
British Slate Association
Clay Roofing Tile Council
Concrete Tile Manufacturers' Association
EURISOL UK Mineral Wool Association
Fibre Cement Manufacturers Association
National Federation of Roofing Contractors
Office of the Deputy Prime Minister — British Board of Agrément
Office of the Deputy Prime Minister — Building Research Establishment
Royal Institute of British Architects
Royal Institution of Chartered Surveyors Building Control Forum
Thermal Insulation Manufacturers and Suppliers Association
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Contents

	Page
Committees responsible	Inside front cover
Foreword	iii
1 Scope	1
2 Normative references	1
3 Terms, definitions and symbols	3
4 Materials, fittings and accessories	9
5 Design criteria	20
6 Application and installation details	53
Annex A (normative) Reinforced bitumen underlays	77
Annex B (normative) Design and installation of pitched roof systems where insulation is placed at rafter line	78
Annex C (normative) Permissible characteristics and defects for grading timber battens and counter-battens	85
Annex D (normative) Preservative treatment for timber battens	90
Annex E (normative) Determination of batten sizes by calculation	90
Annex F (informative) Examples of structural design calculations for tiling battens	92
Annex G (normative) Method of test and calculation for wind uplift resistance of mechanical fasteners for single-lap tiles	97
Annex H (normative) Method of test and calculation for wind uplift resistance of nail hook fixings for double-lap slates	105
Annex I (informative) Worked examples of wind uplift and fixing calculations	109
Annex J (normative) Method of test for determination of tensile adhesion strength of bedding mortars	123
Annex K (normative) Values of uplift pressure reduction factor, R	126
Annex L (normative) Method of test for air permeability of unsealed small element roofing assemblies	126
Bibliography	132
Figure 1 — Drive slate hook dimensions	16
Figure 2 — Categories of exposure to driving rain	21
Figure 3 — Laps for centre-nailed, head-fixed and shoulder-fixed double-lap slates	22
Figure 4 — Pitch of slates in double-lap slating	23
Figure 5 — Key for C_{pt} data for duopitch and hipped roofs	32
Figure 6 — Key for C_{pt} data for monopitch roofs	33
Figure 7 — Distances around obstructions	34
Figure 8 — Wind uplift loading on single-lap tiles, including where the eaves overhang exceeds 50 mm	36
Figure 9 — Wind uplift loading on double-lap slates or tiles, including where the eaves overhang exceeds 50 mm	37
Figure 10 — Wind uplift loading on single-lap tiles where the verge overhang exceeds 50 mm	38
Figure 11 — Wind uplift loading on ridges and hips	40
Figure 12 — Valley gutter with unbedded tiles or slates	53
Figure 13 — Valley gutter with bedded tiles	54
Figure B.1 — Force diagram of vectored load down roof slope	81
Figure B.2 — Bending stress in a fixing through rigid insulation	82
Figure B.3 — Bending moment diagram of a fixing through rigid insulation	82
Figure B.4 — Deflection diagram of a fixing through rigid insulation	83
Figure C.1 — Examples of knot configurations	86
Figure C.2 — Permissible wane	86
Figure C.3 — Permissible depth of fissures	87

	Page
Figure C.4 — Permissible slope of grain	87
Figure C.5 — Permissible rate of growth	88
Figure C.6 — Measurement of distortion	89
Figure F.1 — Loads and bending moments on roof battens	93
Figure G.1 — Example of an arrangement of the test apparatus for determination of clip strength for single-lap tiles	98
Figure G.2 — Example of a hinged batten for supporting a clipped test tile	99
Figure G.3 — Tiles laid in straight bond	100
Figure G.4 — Tiles laid in broken (half) bond	100
Figure G.5 — System of forces in an array of clipped tiles under uplift load	104
Figure H.1 — Example of an arrangement of the test apparatus for determination of nail hook fixing strength for double-lap slates	106
Figure I.1 — Dimensions and forces acting on a single-lap tile	110
Figure I.2 — Dimensions and forces acting on a plain tile	112
Figure I.3 — Wind uplift forces F_{tr} and F_h and the mass of a ridge tile	116
Figure I.4 — Restoring force provided by the mortar on a ridge tile	117
Figure I.5 — Dimensions and forces on centre-nailed double-lap slating with an example of slate hook arrangement	118
Figure I.6 — Dimensions and forces of top-nailed double-lap slating	121
Figure J.1 — Test strip selection from plain tile	124
Figure J.2 — Sample configuration at the time of testing	125
Figure L.1 — Arrangement of apparatus	127
Figure L.2 — Plenum chamber arrangement for air permeability test	129
Table 1 — Minimum timber batten sizes (roofing and vertical work)	12
Table 2 — Dimensions of drive slate hooks	15
Table 3 — Flashings and junctions	17
Table 4 — Values of c for head-lap calculations for double-lap fibre-cement and natural slates, nail-fixed or hook-fixed	26
Table 5 — Minimum head-laps and E_f factors for double-lap fibre-cement and natural slates, pegged, nailed or hook-fixed	27
Table 6 — Pressure difference coefficients (C_{pe}) for duopitch, hipped, and monopitch roofs of clad rectangular buildings	31
Table 7 — Values of air permeability factor D for certain roof covering types laid with unsealed head-laps and side-laps	35
Table 8 — Values of roof substrate shielding factor S for calculating the wind uplift loads on roof coverings laid with unsealed head-laps and side-laps	35
Table 9 — C_{pi} values applicable in cases where the ceiling is permeable or absent	41
Table 10 — Nail penetrations for fixing into timber against wind uplift	42
Table 11 — Values of mortar tensile adhesion strength, S_t	45
Table 12 — Grading envelopes for sands used for mortar samples	45
Table 13 — Minimum spacing of nails and screws	48
Table 14 — Minimum widths of valley gutter for different roof pitches and plan areas	54
Table 15 — Minimum width of lead to line valley gutters for different roof pitches and plan areas	54
Table 16 — Head-laps for underlay	56
Table A.1 — Recommendations for mass per unit area of constituent materials	77
Table E.1 — GS grade bending stresses and moduli for batten timber species	91
Table G.1 — Values of k_n for clips	102
Table H.1 — Values of k_n for slate hooks	108
Table K.1 — Values of uplift pressure reduction factor, R	126
Table L.1 — Arrangement of unsealed elements	128

Foreword

This British Standard has been prepared by Subcommittee B/542/1, under the direction of Technical Committee B/542. BS 5534:2003+A1:2010 supersedes BS 5534:2003, which is withdrawn.

The start and finish of text introduced or altered by Amendment No. 1 is indicated in the text by tags **A1** **A1**. Minor editorial changes are not tagged.

This British Standard was first published as CP 142 in September 1942, revised in January 1958 and April 1968 and converted into a metric version giving values in SI units in October 1971. It was first published as BS 5534-1 in April 1978 and was updated in 1990 and 1997. BS 5534-2 was first published in November 1986, and was withdrawn on publication of BS 5534-1:1997, by which it was superseded.

This edition is a full revision of the standard and incorporates the following main changes.

- a) Clauses have been introduced to reflect the wider range of slating/tiling products now in use and to accommodate the requirements of the Construction Products (Amendment) Regulations 1994 [1].
- b) Clause 5, which deals with recommendations for design, has been revised to reflect the new knowledge and experience on rain resistance and wind load resistance.
- c) The method of calculating minimum head-laps and side-laps in slating, based on angles of creep, has been replaced with a new method based on a series of factors, c and E_1 .
- d) The sections dealing with hook fixing of slates have been revised to provide specific recommendations and limits to their use.
- e) Recommendations on batten sizes, marking identification and structural design have been revised to reflect new test evidence and experience of use, together with new recommendations for marking to enable easier identification.
- f) New annexes have been added dealing with the design and application of pitched roof systems where insulation is placed at rafter line, and reinforced bitumen underlays.

Information relating to the preservative treatment of timber battens has been contributed by the British Wood Preserving and Damp-proofing Association.

Where reference is made to proprietary products and to manufacturers' recommendations, the specifier needs to obtain evidence that these products and recommendations have been proven by relevant experience or relevant test method data based on the conditions and methods of use in the UK climate to be fit for purpose. In cases where the recommendations concerning the use of proprietary products varies from those contained in this British Standard, it is essential that the manufacturer's recommendations give the designer and user adequate assurance of performance. It is advisable that the designer or specifier seeks assurances at the design stage of a project that such recommendations are appropriate.

Product certification. Designers and specifiers are advised to consider the desirability of using roofing products, fittings and accessories that are supported by recognized UKAS-accredited third-party assessment.

This British Standard should be read in conjunction with BS 8000-6.

NOTE Attention is drawn to the Control of Substances Hazardous to Health Regulations 1999 [2].

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

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.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 134, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

1 Scope

This British Standard gives recommendations for the design, materials, application, installation and performance of slates, tiles, shingles and shakes and their associated fittings and accessories used in the construction of pitched roofs and vertical cladding applications. Rain and wind resistance, along with durability, thermal insulation, the control of condensation, fire resistance, sound, environmental and health and safety issues are also considered.

This British Standard does not give recommendations for workmanship, which are included in BS 8000-6.

This British Standard does not give detailed recommendations for the setting out and construction of special roof types such as curved or random slating, but it does give recommendations for determining minimum roof pitches and calculating the minimum head-laps and side-laps that can be used for such types of slating.

This British Standard is intended for use by designers, manufacturers and installers of roofing products.

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 416-1, *Discharge and ventilating pipes and fittings, sand-cast or spun in cast iron — Part 1: Specification for spigot and socket systems.*

BS 680-2, *Specification for roofing slates — Part 2: Metric units.*

BS 890, *Specification for building limes.*

BS 1042 (ISO 3966) (all parts), *Measurement of fluid flow in closed conduits.*

BS 1105, *Specification for wood wool cement slabs up to 125 mm thick.*

BS 1202-1, *Specification for nails — Part 1: Steel nails.*

BS 1202-2, *Specification for nails — Part 2: Copper nails.*

BS 1202-3, *Specification for nails — Part 3: Aluminium nails.*

BS 1297, *Specification for tongued and grooved softwood flooring.*

BS 1449-1 (all sections), *Steel plate, sheet and strip — Part 1: Carbon and carbon-manganese plate, sheet and strip.*

BS 1554:1990, *Specification for stainless and heat-resisting steel round wire.*

BS 2000-49 (BS EN 1426), *Methods of test for petroleum and its products — Part 49: Bitumen and bituminous binders — Determination of needle penetration.*

BS 2000-58 (BS EN 1427), *Methods of test for petroleum and its products — Part 58: Bitumen and bituminous binders — Determination of softening point — Ring and ball method.*

BS 3177, *Method for determining the permeability to water vapour of flexible sheet materials used for packaging.*

BS 3690-2, *Bitumens for building and civil engineering — Part 2: Specification for bitumens for industrial purposes.*

BS 4551 (all parts), *Methods of testing mortars, screeds and plasters.*

BS 4576-1, *Unplasticized polyvinyl chloride (PVC-U) rainwater goods and accessories — Part 1: Half-round gutters and pipes of circular cross-section.*

BS 4887-1, *Mortar admixtures — Part 1: Specification for air-entraining (plasticizing) admixtures.*

BS 5250:2002, *Code of practice for control of condensation in buildings.*

BS 5268-2, *Structural use of timber — Part 2: Code of practice for permissible stress design, materials and workmanship.*

BS 5628-3:2001, *Code of practice for use of masonry — Part 3: Materials and components, design and workmanship.*

- BS 6100-1.3.1:1992, *Glossary of building and civil engineering terms — Part 1: General and miscellaneous — Section 1.3: Parts of construction works — Subsection 1.3.1: Walls and cladding.*
- BS 6100-1.3.2:1989, *Glossary of building and civil engineering terms — Part 1: General and miscellaneous — Section 1.3: Parts of construction works — Subsection 1.3.2: Roofs and roofing.*
- BS 6229, *Code of practice for flat roofs with continuously supported coverings.*
- BS 6399 (all parts), *Loading for buildings.*
- BS 6651, *Code of practice for protection of structures against lightning.*
- BS 7916, *Code of practice for the selection and application of particleboard, oriented strand board (OSB), cement bonded particleboard and wood fibreboards for specific purposes.*
- BS 8000-6:1990, *Workmanship on building sites — Code of practice for slating and tiling of roofs and claddings.*
- BS 8417, *Preservation of timber — Recommendations.*
- BS EN 197-1:2000, *Cement — Part 1: Composition, specifications and conformity criteria for common cements.*
- BS EN 300, *Oriented strand boards (OSB) — Definitions, classification and specifications.*
- BS EN 312-5, *Particleboards — Specifications — Part 5: Requirements for load-bearing boards for use in humid conditions.*
- BS EN 312-7, *Particleboards — Specifications — Part 7: Requirements for heavy-duty load-bearing boards for use in humid conditions.*
- BS EN 313 (all parts), *Plywood — Classification and terminology.*
- BS EN 485-1:1994, *Aluminium and aluminium alloys — Sheet, strip and plate — Part 1: Technical conditions for inspection and delivery.*
- BS EN 485-2:1995, *Aluminium and aluminium alloys — Sheet, strip and plate — Part 2: Mechanical properties.*
- BS EN 485-4:1994, *Aluminium and aluminium alloys — Sheet, strip and plate — Part 4: Tolerances on shape and dimensions for cold-rolled products.*
- BS EN 490, *Concrete roofing tiles and fittings — Product specifications.*
- BS EN 491, *Concrete roofing tiles and fittings — Test methods.*
- BS EN 492, *Fibre-cement slates and their fittings for roofing — Product specification and test methods.*
- BS EN 516:1995, *Prefabricated accessories for roofing — Installations for roof access — Walkways, treads and steps.*
- BS EN 517, *Prefabricated accessories for roofing — Roof safety hooks.*
- BS EN 539-2, *Clay roofing tiles for discontinuous laying — Determination of physical characteristics — Part 2: Test for frost resistance.*
- BS EN 544, *Bitumen shingles with mineral and/or synthetic reinforcements.*
- BS EN 573 (all parts), *Aluminium and aluminium alloys — Chemical composition and form of wrought products.*
- BS EN 599-1, *Durability of wood and wood-based products — Performance of preservatives as determined by biological tests — Part 1: Specification according to hazard class.*
- BS EN 607, *Eaves gutters and fittings made of PVC-U — Definitions, requirements and testing.*
- BS EN 612, *Eaves gutters and rainwater down-pipes of metal sheet — Definitions, classifications and requirements.*
- BS EN 622-3, *Fibreboards — Specifications — Part 3: Requirements for medium boards.*
- BS EN 634-2, *Cement-bonded particle boards — Specification — Part 2: Requirements for OPC bonded particleboards for use in dry, humid and exterior conditions.*
- BS EN 635 (all parts), *Plywood — Classification by surface appearance.*
- BS EN 988, *Zinc and zinc alloys — Specification for rolled flat products for building.*

BS EN 1172, *Copper and copper alloys — Sheet strip for building purposes.*

BS EN 1304, *Clay roofing tiles for discontinuous laying — Product definitions and specifications.*

BS EN 10048, *Hot rolled narrow steel strip — Tolerances on dimensions and shape.*

BS EN 10051, *Specification for continuously hot-rolled uncoated plate, sheet and strip of non-alloy and alloy steels — Tolerances on dimensions and shape.*

BS EN 10095, *Heat resisting steels and nickel alloys.*

BS EN 10230-1, *Steel wire nails — Part 1: Loose nails for general applications.*

BS EN 10258, *Cold-rolled stainless steel narrow strip and cut lengths — Tolerances on dimensions and shape.*

BS EN 12056-3, *Gravity drainage systems inside buildings — Part 3: Roof drainage, layout and calculation.*

BS EN 12588:1999, *Lead and lead alloys — Rolled lead sheet for building purposes.*

BS EN 12878, *Pigments for the colouring of building materials based on cement and/or lime — Specifications and methods of test.*

BS EN ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles — Specification and test methods.*

BS EN ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system.*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this British Standard, the definitions given in BS 6100-1.3.1 and BS 6100-1.3.2 and the following apply.

3.1.1 air spaces

3.1.1.1

non-ventilated air space

cavity or void that has no openings to the outside air, but which allows water vapour transfer across it by diffusion

3.1.1.2

ventilated air space

cavity or void that has openings to the outside air, designed and placed so as to provide the through-movement of air

3.1.2

convection-tight

sealed by the use of airtight joints and seals so as to prevent the free movement of air through any section of the construction or assembly

NOTE A convection-tight roof system is also known as an airtight roof system.

3.1.3 laps

3.1.3.1

sealed lap

lap in slates and tiles that has been sealed by the application of bitumen, resins, foams, membranes, torching, etc.

3.1.3.2

unsealed lap

lap in slates and tiles that has not been deliberately sealed by the application of bitumen, resins, foams, membranes, torching, etc.

3.1.4 pitched roofs

3.1.4.1

non-ventilated and insulated pitched roof

thermally insulated pitched roof without a ventilated zone between the thermal insulation layer and the roof covering

3.1.4.2

ventilated and insulated pitched roof

thermally insulated pitched roof with a ventilated zone between the thermal insulation layer and the roof covering

3.1.5

rafter pitch

angle of elevation of a roof structure from the horizontal

3.1.6 rain

3.1.6.1

deluge rain

high rainfall without wind

3.1.6.2

driving rain

rainfall with wind

NOTE This is also known as “wind-driven rain”.

3.1.7

roof

part of a building with a pitch greater than 10° and less than 75°

NOTE Attention is drawn to the Building Regulations 2000 and subsequent amendments [3], Approved Documents L1 and L2, which state that any part of a roof having a pitch of 70° or more can be considered as a wall.

3.1.8

snow

snowfall with or without wind

3.1.9

tenting

transfer of moisture through a permeable material, initiated by contact

3.1.10 underlays

3.1.10.1

high water vapour resistance (type HR) underlay

underlay that has a water vapour resistance in excess of $50 \text{ MN}\cdot\text{s/g}$, which effectively prevents the transfer of water vapour

3.1.10.2

low water vapour resistance (type LR) underlay

underlay that has a water vapour resistance not more than $0.25 \text{ MN}\cdot\text{s/g}$, which allows for the transfer of water vapour

NOTE Type LR underlays are sometimes referred to as “vapour-permeable”, “vapour-open” or “breather” underlays.

3.1.11

vapour control layer (VCL)

construction material, usually a membrane, that substantially reduces the water vapour transfer (as defined in BS 5250) through any part of a building in which it is incorporated

NOTE BRE 262 [4] specifies a minimum water vapour resistance of $200 \text{ MN}\cdot\text{s/g}$. BS 5250 refers to the use of 500 gauge polyethylene with a range of $200 \text{ MN}\cdot\text{s/g}$ to $300 \text{ MN}\cdot\text{s/g}$, typically $250 \text{ MN}\cdot\text{s/g}$.

3.2 Symbols

For the purposes of this British Standard, the following symbols apply.

NOTE The symbols apply throughout the entire standard, including the annexes. Some symbols are used only in the annexes.

A	valley width, in millimetres (mm)
A_h	horizontally projected area of a ridge or hip tile, in square metres (m ²)
A_{hk}	angle of the spike of a slate hook, in degrees (°)
A_{oe}	exposed overhanging area of a roofing element at the eaves, in square metres (m ²)
A_{ov}	exposed overhanging area of a roofing element at the verge, in square metres (m ²)
A_r	effective test rig area, in square metres (m ²)
A_t	exposed area of a roofing element, in square metres (m ²)
A_{te}	exposed area of part of a roofing element at the eaves that is protected by the underlay, in square metres (m ²)
A_{tr}	vertically projected area of a ridge or hip tile, in square metres (m ²)
A_{tv}	exposed area of part of a roofing element at the verge that is protected by the underlay, in square metres (m ²)
a	contact surface area of the smallest two tile coupons comprising a test sample, in square millimetres (mm ²)
B	cover width of a roofing element, in metres (m)
B_h	distance from the top edge of a slate to the inner edge of the nail or peg hole of head-fixed or shoulder-fixed slates, in metres (m)
B_n	distance from the side edge of a slate to the inner edge of the nail hole, in metres (m)
B_r	length of a ridge or hip tile, in metres (m)
B_o	overhanging width of a roofing element, in metres (m)
B_{v1}	tile/slate overhang to a tilting fillet, in millimetres (mm)
B_{v2}	clear channel between bedding and tilting fillet, in millimetres (mm)
b_{min}	minimum width of a slate, in metres (m)
C_a	size effect factor [BS 6399-2]
C_{dk}	characteristic hook deformation load, in newtons (N)
C_{hk}	characteristic hook failure load, in newtons (N)
C_{pe}	external pressure coefficient [BS 6399-2]
C_{pi}	internal pressure coefficient for the underside of an element
C_{pt}	pressure difference coefficient
c	driving rain head-lap factor for slates, in metres (m)
$\bar{c}$	average failure load of a hook from a population of n samples, in newtons (N)
c_{hk}	individual hook failure load, in newtons (N)
D	air permeability factor
D_{hk}	length of the spike of a slate hook, in millimetres (mm)
d	depth of a timber batten, in millimetres (mm)
d_{hk}	distance from the centre of mass of a metal test slate to the hinge of the top batten in the hook test, in metres (m)
d_{max}	maximum displacement of tile D in Figure G.1, in millimetres (mm)
d_n	pointside penetration of a nail into timber, in millimetres (mm)
d_{ns}	diameter of a screw or nail, in millimetres (mm)
d_{pc}	critical pressure difference, in newtons per square metre (N/m ²)
E	module of elasticity of a fixing, in newtons per square millimetre (N/mm ²)

E_l	driving rain side-lap factor for slates
F_{hk}	resistance force applied to a slate perpendicular to the slate surface in the hook test, in newtons (N)
F_{SRC}	load on a fixing down the roof slope due to a concentrated imposed load and roof dead load, in newtons (N)
F_{SRI}	load on a fixing down the roof slope due to a uniformly distributed imposed load and roof dead load, in newtons (N)
F_T	test load, in newtons (N)
$F_{T, MAX}$	maximum test load at failure, in newtons (N)
F_{T0}	test load without a clip fitted, in newtons (N)
F_c	holding down force applied by a clip to resist wind uplift, in newtons (N)
F_h	horizontal wind shear force on a ridge tile or hip tile, in newtons (N)
F_{oe}	wind uplift force on the overhanging part of the exposed area of an eaves tile or slate, in newtons (N) (negative values denote uplift)
F_{ov}	wind uplift force on the overhanging part of the exposed area of a verge tile or slate, in newtons (N) (negative values denote uplift)
F_t	wind uplift force acting in the centre of the exposed area of a tile or slate, in newtons (N)
F_{te}	wind uplift force on the non-overhanging part of the exposed area of an eaves tile or slate, in newtons (N) (negative values denote uplift)
F_{thk}	load applied at the centre of an exposed area perpendicular to the metal slate surface in the hook test, in newtons (N)
F_{tr}	perpendicular wind uplift force on a ridge tile or hip tile, in newtons (N) (negative values denote uplift)
F_{tv}	wind uplift force on the non-overhanging part of the exposed area of a verge tile or slate, in newtons (N) (negative values denote uplift)
f_{bf}	maximum bending stress in a fixing, in newtons per square millimetre (N/mm ²)
f_x	extreme fibre bending stress about the x–x axis in Figure F.1a), in newtons per square millimetre (N/mm ²)
f_y	extreme fibre bending stress about the y–y axis in Figure F.1a), in newtons per square millimetre (N/mm ²)
G_a	batten gauge, in metres (m)
G_d	general roof area for duopitch and hipped roofs
G_{hk}	length of the part of a slate hook which grips the slate, in millimetres (mm)
G_m	general roof area for monopitch roofs
g	acceleration due to gravity (9.81 m/s ²)
H	building height, in metres (m) [BS 6399-2]
H_i	inner hip local roof area for duopitch and hipped roofs
h_g	nail holing gauge for double-lap slating, in metres (m)
h_l	head-lap for double-lap slating, in metres (m)
h_r	height of ridge tile or hip tile, in metres (m)
I	second moment of area of a fixing, in millimetres to the power 4 (mm ⁴)
I_x	second moment of area of a batten in the x–x axis in Figure F.1a), in millimetres to the power 4 (mm ⁴)
I_y	second moment of area of a batten in the y–y axis in Figure F.1a), in millimetres to the power 4 (mm ⁴)
K	pressure drop coefficient
K_b	depth factor for strength of a batten
K_n	nail resistance factor (used for nailing an occasional course of tiles)

K_1	maximum dimension of a knot on the face of a timber batten, in millimetres (mm)
K_2	minimum dimension of a knot on the opposite face of a timber batten, in millimetres (mm)
k_n	factor depending on the number of tests conducted in Annex G and Annex H
L	building length, in metres (m) [BS 6399-2]
L_b	effective span of a batten, in metres (m)
L_c	distance between the pivot line and the centre of a clip, in metres (m)
L_d	local roof area for duopitch and hipped roofs
L_f	distance between the pivot line and the applied uplift force of a clip, in metres (m)
L_h	hanging length of a roofing element, in metres (m)
L_{hk}	hook length, in millimetres (mm)
L_m	local roof area for monopitch roofs
L_n	lever arm of a nail, in metres (m)
L_o	overhanging length (up the rafter line) of a tile/slate, in metres (m)
L_p	pointside penetration into a batten, in millimetres (mm)
L_r	width of a ridge or hip tile, in metres (m)
L_s	hanging length minus batten gauge (G_a), in metres (m)
L_t	overall length of a slate or tile, in metres (m)
L_v	length of a valley component, in metres (m)
L_w	distance from the centre of gravity of a sample to its uppermost line of support, or the batten, in metres (m)
l	length (parallel to the rafters) of a local roof area, in metres (m)
l_b	length of imposed line load on a batten, in metres (m)
l_h	hanging length of a tile, in millimetres (mm)
M	maximum bending moment in a fixing, in newton millimetres (N·mm)
M_T	total overturning moment, in newton metres (N·m)
M_{hk}	resistance moment of a slate hook, in newton metres (N·m)
M_n	nail withdrawal resistance moment, in newton metres (N·m)
M_r	total restoring moment due to a slate's mass and fixings, in newton metres (N·m)
M_u	wind uplift moment, in newton metres (N·m)
M_w	moment provided by the mass of a slate or tile, in newton metres (N·m)
M_x	bending moment of a batten about the x-x axis in Figure F.1a), in newton metres (N·m)
M_y	bending moment of a batten about the y-y axis in Figure F.1a), in newton metres (N·m)
N_d	nail shank diameter, in millimetres (mm)
n	number of tests conducted
n_c	number of courses of roofing elements held down by one nailed course
n_u	number of unsealed roofing elements under test
P_u	pressure acting on an underlay, in newtons per square metre (N/m ²)
p	moment arm, in metres (m)
p_n	nail penetration, in millimetres (mm)
Q_c	volume flow rate, in cubic metres per second (m ³ /s)
q	moment arm, in metres (m)
q_s	dynamic pressure of the wind, in newtons per square metre (N/m ²) [BS 6399-2]
R	uplift pressure reduction factor
R_F	fixing spacing in a continuous counter-batten, in metres (m)
R_R	rafter spacing, in metres (m)

R_c	design value of fastener uplift resistance, in newtons (N)
R_{hk}	maximum design value of hook resistance, in newtons (N)
R_{in}	inner ridge local roof area for duopitch and hipped roofs
R_i	individual fastener uplift resistance, in newtons (N)
R_k	characteristic value of fastener uplift resistance, in newtons (N)
R_n	recommended fixing resistance, in newtons (N)
R_s	rafter spacing, in metres (m)
R_x	average failure load of a clip from a population of n samples, in newtons (N)
r	moment arm, in metres (m)
r_n	nail basic withdrawal load, in newtons per millimetre (N/mm)
S	roof substrate shielding factor
S_m	failure load, in newtons (N)
S_n	test value of mortar strength, in newtons per square millimetre (N/mm ²)
S_t	permissible mortar tensile adhesion strength, in newtons per square millimetre (N/mm ²)
S_w	safety factor applied to the mass of a roofing element
s_f	standard deviation of fastener uplift resistance, in newtons (N)
s_l	side-lap for double-lap slating, in metres (m)
s_{min}	minimum side-lap for double-lap slating, in metres (m)
s_y	batten deflection in the y–y axis in Figure F.1a), in millimetres (mm)
T_{hk}	dimension of the crimp of a slate hook, in millimetres (mm)
t	slate thickness, in metres (m)
t_{ins}	thickness of insulation, in millimetres (mm)
U_{hk}	gap in a slate hook which grips the slate, in millimetres (mm)
V_e	effective wind speed, in metres per second (m/s) [BS 6399-2]
W	building width, in metres (m) [BS 6399-2]
W_a	restoring force due to the mass per unit area of a tile and the acceleration due to gravity of a roofing element, in newtons per square metre (N/m ²)
W_p	restoring force due to the mass of a roofing element and the acceleration due to gravity acting perpendicular to the plane of a roof slope, in newtons (N)
W_t	mass of a roofing element, in kilograms (kg)
w	width (parallel to the battens) of a local roof area, in metres (m)
w_d	mass per unit area of a roofing element, in newtons per square metre (N/m ²)
w_i	imposed load applied vertically, in newtons per square metre (N/m ²)
w_p	concentrated (point) load applied vertically, in newtons (N)
w_v	vertical load on a batten, in kilonewtons per metre (kN/m)
w_x	component load on a batten in the x–x axis in Figure F.1a), in kilonewtons per metre (kN/m)
w_y	component load on a batten in the y–y axis in Figure F.1a), in kilonewtons per metre (kN/m)
X	dimension of a roof obstruction, in metres (m)
X_d	area to be drained, in square metres (m ²)
x	dimension of the local area surrounding a roof obstruction, in metres (m)
Y	dimension of a roof obstruction, in metres (m)
y	dimension of the local area surrounding a roof obstruction, in metres (m)
y_{hk}	distance from the centre of the exposed area of a test sample to the hinge of the top batten in the hook test, in metres (m)
Z	dimension of a roof obstruction, in metres (m)
Z_f	section modulus of a fixing, in cubic millimetres (mm ³)

Z_x	section modulus of a timber batten in the x–x axis in Figure F.1a), in cubic millimetres (mm ³)
Z_y	section modulus of a timber batten in the y–y axis in Figure F.1a), in cubic millimetres (mm ³)
z_{hk}	distance from the point at which a hook grips a test sample to the hinge of the top batten in the clip test, in metres (m)
α	pitch of a roof, from the horizontal, in degrees (°) [BS 6399-2]
δ	deflection of a fixing through insulation, in millimetres (mm)
θ	pitch of a laid slate, tile or shingle from the horizontal, in degrees (°)
σ	standard deviation for tests on the strength of slate hooks
τ	conversion factor used in determining nail penetrations
$\varnothing$	diameter of a slate hook shank, in millimetres (mm)

4 Materials, fittings and accessories

NOTE 1 Users of this British Standard are advised to refer to accreditation certificates and manufacturers' technical data relevant to the conditions of use in the UK.

NOTE 2 Attention is drawn to HSG 33 [5], which applies to all types of roofing work during construction of new work or in the maintenance and repair of existing roofs. Roofs of slates, tiles or shingles are regarded as fragile during construction.

4.1 Use of generic or proprietary products

This British Standard makes frequent reference to the use of generic or proprietary products.

In cases where the manufacturer's recommendations concerning the use of a proprietary product vary from the recommendations given in this British Standard, it is essential that the designer and user seek evidence that the product is fit for its intended purpose when used in accordance with the manufacturer's recommendations. Such products should be used only if this evidence is available.

Proprietary products not referred to in this British Standard may be specified and used provided that the product has been proven by long-term relevant experience in use and/or relevant test data to be fit for purpose when used in accordance with the manufacturer's recommendations. Where such products are used, the manufacturer's recommendations should be followed.

NOTE When using proprietary roofing products, fittings and accessories, including composite, resin-filled, bonded or lightweight products, etc., designers and specifiers are advised to consider the desirability of using products that are supported by recognized UKAS-accredited third-party assessment.

4.2 Clay tiles and fittings (single-lap and double-lap)

Clay tiles and fittings (single-lap and double-lap) should conform to BS EN 1304.

4.3 Concrete tiles and fittings (single-lap and double-lap)

Concrete tiles and fittings (single-lap and double-lap) should conform to BS EN 490.

4.4 Fibre-cement slates and fittings

Fibre-cement slates should conform to BS EN 492. All fibre-cement fittings should conform to the relevant quality and durability requirements specified in BS EN 492.

NOTE In the maintenance and repair of existing roofs containing asbestos-containing materials (ACMs), e.g. where asbestos cement products which contain only chrysotile asbestos fibres are present, attention is drawn to the Control of Asbestos at Work Regulations 2002 [6], which require health and safety precautions to be taken. See also HSG 33 [5]. If work involving asbestos insulating board (AIB), asbestos coating or asbestos insulation is to be carried out, contractors are required to be licensed by the HSE's Asbestos Licensing Unit.

4.5 Natural slates and fittings

Natural slates should conform to BS 680-2.

NOTE A European Standard for natural slates, prEN 12326-1, is in preparation. A British Standard for natural slates test methods, BS EN 12326-2, has been published.

4.6 Bitumen shingles

Bitumen shingles with mineral and/or synthetic reinforcement should conform to BS EN 544.

4.7 Wooden shingles and shakes

NOTE 1 There is no British Standard for wooden shingles and shakes.

Wooden shingles and shakes should be treated to provide enhanced durability.

NOTE 2 See also NFRC Technical Bulletin 34 [7].

4.8 Metal tiles

NOTE There is no British Standard for metal tiles.

Metal tiles should be manufactured from corrosion-resistant metals or metals of adequate strength, treated to provide durability.

4.9 Valley units (preformed)

Proprietary valley units that include preformed GRP, PVC-U and metal products, etc., should be of sufficient strength, water impermeability and geometric dimensions to ensure durability.

NOTE 1 When using proprietary valley units, designers and specifiers are advised to consider the desirability of using products that are supported by recognized UKAS-accredited third-party assessment.

NOTE 2 See also NFRC Technical Bulletin 28 [8].

4.10 Roofing underlay

4.10.1 General

Roofing underlay should:

- a) provide a barrier to minimize the wind uplift load acting on the slates or tiles;
- b) provide a secondary barrier to the ingress of wind-driven snow and dust (products conforming to the material specifications recommended in this British Standard are deemed to be satisfactory);
- c) transport into the roof drainage system any moisture in the batten space;
- d) provide temporary, i.e. less than 3 months, weather protection (including rain impact resistance) before the installation of the primary roof covering.

NOTE 1 Neither Annex A, BS 747, nor prEN 13859-1 for underlays include a test for rain impact resistance and advice should be sought from manufacturers on the temporary weather protection performance of their products.

Underlays should be capable of withstanding the following conditions.

- 1) *Tenting*. Neither Annex A, BS 747, nor prEN 13859-1 for underlays include a test for tenting. Where tenting is a possibility, avoid contact of roofing components with the underside of the underlay at points where the external surface of the underlay could be subject to moisture. Materials that are susceptible to tenting should not be used.
- 2) *Fixing penetrations*. Nail holes through underlays should not be subject to enlargement due to shrinkage.

NOTE 2 prEN 13859-1 gives a test method for determining shrinkage; the maximum permissible shrinkage when tested in accordance with this method is 0.5 %.

NOTE 3 When the European Standard for underlays (prEN 13859-1) is published, products having a water penetration classification of class A in accordance with that standard will be deemed to be suitable for use in UK conditions.

Underlays may be used as a temporary covering over continuous sarking boards, remaining in position after the fixing of slates, which are nailed through the underlay to softwood boarding, as in Scottish practice.

4.10.2 Fully supported

The roofing underlay should be of suitable strength, water resistance and durability for the proposed application and this should be confirmed with the underlay manufacturer. It should also have water vapour transmission high enough to prevent the formation of condensation beneath the underlay. For underlays on timber sarking, it is recommended that when tested in accordance with BS 3177, the permeability be not less than 36 g/m² per 24 h at 25 °C with a relative humidity of 75 %. For underlays supported on other materials, see Annex B and BS 5250.

NOTE The unit of permeability 36 g/m² per 24 h can be expressed as either:

- a maximum vapour resistance of 5.7 MN·s/g; or
- a maximum vapour diffusion thickness value of 1.1 m.

4.10.3 *Unsupported*

Reinforced bituminous flexible underlays should conform to the recommendations for type 1F or type 5U given in Annex A.

NOTE 1 When using proprietary roofing underlays, designers and specifiers are advised to consider the desirability of using products that are supported by recognized UKAS-accredited third-party assessment. Attention is particularly drawn to the need for adequate water resistance, tensile and nail-tear resistance, water vapour permeability (where required) and durability.

NOTE 2 Refer also to NFRC Technical Bulletin 6 [9].

4.10.4 *Flexible and rigid underlays*

Non-bituminous flexible underlays should generally meet the recommendations of Annex A (see Note 1).

NOTE 1 Flexible underlays not conforming to Annex A may be used provided that the specifier has obtained evidence that these products and recommendations have been proven by relevant experience or relevant test method data based on the conditions and methods of use in the UK climate to be fit for purpose. Designers and specifiers are advised to consider the desirability of using flexible underlays that are supported by recognized UKAS-accredited third-party assessment.

Flexible underlays should be sufficiently flexible at low temperatures to reduce the risk of damage and difficult handling during installation.

NOTE 2 Products that meet the requirements of prEN 13859-1 cold bend temperature of -10°C are deemed to have sufficient flexibility.

NOTE 3 There is no British Standard for rigid underlays. Rigid underlays are deemed to be suitable for use if there is a recognized UKAS-accredited third-party product certificate for their use in UK conditions.

4.11 Boarding, sheathing and sarking

Boarding, sheathing and sarking should be either tongued and grooved or square-edged. Tongued and grooved boarding should conform to BS 1297. Plywoods should be selected from those listed in BS EN 635, BS EN 313-1, BS EN 313-2 and BS 5268-2.

Wood wool slabs should conform to BS 1105. Fibreboards should conform to the recommended types for sarking and sheathing given in BS EN 622-3.

NOTE 1 Insulation boards used as sarking are not included in this British Standard.

Particle boards, type C3, C4 or CS wood chipboard should conform to BS EN 312-5 and BS EN 312-7.

Orientated strand board type OSB3 or OSB4 should conform to BS 7916 and BS EN 300.

Cement bonded particleboard should conform to BS EN 634-2.

NOTE 2 Other manufactured boards may be used provided that the specifier has obtained evidence that these products and recommendations have been proven by relevant experience or relevant test method data based on the conditions and methods of use in the UK climate to be fit for purpose.

4.12 Timber battens and counter-battens

4.12.1 *Timber species*

Timber battens and counter-battens should be of the following species¹⁾:

a) imported:

- redwood [PNSY²⁾];
- whitewood [WPCA];
- spruce-pine-fir (USA, Canada) [WPCE];
- southern pine (USA) [WPNE];

b) British-grown³⁾:

- larch [WLAD];
- British pine [WPNN];
- British spruce [WPCS].

¹⁾ The species names are those given in BS 5268-2.

²⁾ ^{A1} The four-letter codes in parentheses denote the abbreviated species identification codes given in BS EN 13556. ^{A1}

³⁾ For the purposes of this British Standard, "British-grown" species are those grown in the United Kingdom and the Irish Republic.

4.12.2 Permissible characteristics and defects

Characteristics and defects in timber battens should not exceed the limits given in Annex C.

A1 Timber battens should be graded in accordance with Annex C and marked in accordance with 4.12.5.2.

NOTE When using machine graded battens, designers and specifiers are advised to consider the desirability of using products that are supported by United Kingdom Accreditation Service (UKAS) accredited third-party assessment. **A1**

4.12.3 Preservative treatment

Expected in-service conditions indicate whether or not to treat tiling or slating battens with a preservative (see Note 1). Guidance is provided in Annex D. If preservative treatment is necessary, it should be carried out in accordance with Annex D.

NOTE 1 Attention is drawn to the Building Regulations 2000 and subsequent amendments [3] and local byelaws with regard to preservative treatment in areas subject to attack by the House Longhorn beetle.

NOTE 2 Impregnation with preservative can be particularly useful in cases where maximum durability is sought or where there is a high risk of condensation or lack of ventilation.

4.12.4 Sizes

4.12.4.1 Minimum sizes

A1 Text deleted. **A1**

Timber batten sizes should be not less than the minimum values recommended in Table 1 for the common applications listed.

Table 1 — Minimum timber batten sizes (roofing and vertical work)

Application	Basic minimum size of batten ^{a b c}			
	Up to 450 mm span ^d		Up to 600 mm span ^d	
	Width mm	Depth mm	Width mm	Depth mm
Slates (double-lap):				
— natural: sized or random	50	25	50	25
— fibre-cement or concrete	38	25	50	25
Clay and concrete tiles:				
— double-lap	38	25	38	25
— single-lap	38	25	50	25

^a Tolerances on the basic sizes of timber batten should be: width ± 3 mm, depth ${}_{-3}^0$ mm, based on measurement at a reference moisture content of 20 % (see Annex C).

^b These minimum sizes do not apply to battens used to support ridges, hips and valleys.

^c Batten sizes for other slates, tiles and shingles such as timber shingles and shakes and metal tiles, or other proprietary roofing products, should be in accordance with the manufacturer's recommendations.

^d Span is defined as the distance between centres of supports, or the clear distance between the face of supports plus half the bearing length at each end support, whichever is the lesser. The end-bearing length should be not less than 17.5 mm.

4.12.4.2 Other sizes

Battens for spans greater than those given in Table 1, or for other loading conditions, should be designed by structural calculation for strength and stiffness in accordance with Annex E but their sizes should be not less than those given in Table 1 for the relevant application. The batten size for natural slating should be not less than 50 mm × 25 mm irrespective of strength and stiffness calculation.

All batten sizes are subject to the tolerances given in Table 1 and to the permissible characteristics and defects given in Annex C.

NOTE 1 Examples of battens designed by calculation are given in Annex F.

Battens are expected to resist the loadings on the completed slate or tile roof but will not necessarily provide a safe place of work for the slater/tiler.

NOTE 2 Attention is drawn to HSG 33 [5], which requires the roofing operative to have a safe place of work and a platform with safe access to work.

NOTE 3 Attention is drawn to the Construction (Design and Management) (Amendment) Regulations 2000 [10] in respect of the adequacy of battens as a safe working platform for the span at which they are to be employed.

4.12.4.3 *Minimum batten length*

Where there are at least three supports, batten lengths should be sufficient to span over not less than three supports.

4.12.4.4 *Counter-battens*

The dimensions of counter-battens should be sufficient to provide a ventilation gap as recommended in BS 5250 and/or to provide a drainage path beneath the battens.

4.12.5 *Identification*

4.12.5.1 *Documentation*

Each delivery of battens should be accompanied by documentation stating at least the following:

- a) name of supplier;
- b) origin (imported or British-grown, and/or species code – see 4.12.1);
- c) graded in accordance with BS 5534⁴⁾;
- d) basic size or sizes;
- e) type of preservative and method of treatment, if applicable.

NOTE 1 See also NFRC Technical Bulletin 33 [11].

NOTE 2 See Annex D for further guidance on preservative treatment.

4.12.5.2 *Marking*

Each batten should be indelibly marked with the following information:

- a) supplier;
- b) origin (imported or British-grown, and/or species code – see 4.12.1);
- c) “graded BS 5534”⁴⁾;
- d) size.

4.13 *Mechanical fixings*

4.13.1 *Nails*

4.13.1.1 *General*

For nails intended to be used as fixings:

- steel nails should conform to BS EN 10230-1 or, for nail types not included in that standard, BS 1202-1;
- stainless steel nails should conform to BS 1554:1990, grade 302, 304, 316, 321 or 347;
- copper nails should conform to BS 1202-2;
- aluminium nails should conform to BS 1202-3;
- phosphor or silicon-bronze nails should be in accordance with the manufacturer’s specification;
- zinc-coated steel nails should be coated using any one of the zinc or zinc alloy coating methods specified in BS EN 10230-1;
- nails made of other materials should be in accordance with the manufacturer’s specification.

⁴⁾ Marking BS 5534:2003 on or in relation to a product represents a manufacturer’s declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the recommendations of the standard. The accuracy of the claim is solely the claimant’s responsibility. Such a declaration is not to be confused with third-party certification of conformity.

When selecting the type of nail for each application, consideration should be given to the effects of its mechanical and chemical properties in relation to other metals or chemical salts that might be present in its final location.

4.13.1.2 Nails for battens, counter-battens, boarding and roofing underlays

Nails for use with battens, counter-battens and boarding (board sarking) should conform to BS EN 10230-1.  For extra protection and in coastal regions, they should be coated by zinc or zinc alloy coating methods specified in BS EN 10230-1.

NOTE Timber containing copper-based preservative can cause aggressive corrosion of uncoated mild steel nails in the presence of moisture. 

For battens and counter-battens they should generally be round plain shank of not less than 3.35 mm shank diameter. Indented, spiral roll and annular shank nails may also be used. The length and type of nail to be used should depend on the exposure of the site (see 5.5.2.8). Special nails should be used for masonry wall applications.

Nails for use with boarding should be round plain shank of not less than 3.35 mm shank diameter brad oval, or cut floor brads, with a minimum of 40 mm penetration into the supporting element.

Nails for use with roofing underlays should be clout head-nails of not less than 3.0 mm shank diameter and 20 mm length made of copper; aluminium alloy or steel coated by any of the zinc or zinc alloy coating methods specified in BS EN 10230-1.

4.13.1.3 Nails for clips

Nails intended for use with clips should be aluminium or stainless steel. The type, shank diameter and length should be determined by the type of clip, batten dimensions and the exposure of the site (see 5.5.3.3.2).

4.13.1.4 Nails for slates, tiles and shingles

Nails intended for use with slates should be of copper, aluminium, phosphor or silicon bronze. Nails intended for use with tiles should be of copper, aluminium, stainless steel, phosphor or silicon bronze. Nails intended for use with wooden shingles should be of aluminium, steel, coated using any one of the zinc or zinc alloy coating methods specified in BS EN 10230-1, phosphor or silicon bronze.

Copper nails intended for use with slates, tiles or shingles/shakes should conform to the requirements for clout nails specified in BS 1202-2 but with dimensions as recommended below. Aluminium nails intended for use with slates, tiles or shingles should conform to BS 1202-3 but with dimensions as recommended below.

NOTE Where shingles or shakes are pressure treated for durability the use of aluminium nails is not recommended.

For natural slates, tiles and artificial slates, the shank diameter and length should be determined by the exposure of the site, the nail's withdrawal resistance and the manufacturer's recommendations (see 5.5.3.3.2). For natural slates the head diameter should be not less than 10 mm (see 5.5.3.4.4) (3.0 mm shanks with 10 mm heads are available). For fibre-cement slates and wooden shingles/shakes the nail shank diameter should be not less than 2.65 mm (see 5.5.3.4.4 and 5.5.3.4.6). For double-lap clay and concrete tiles, smooth aluminium clout head-nails with a shank diameter of not less than 2.65 mm and a length of not less than 38 mm should be used.

4.13.2 Clips for tiles

Where clips are to be used for securing tiles, evidence should be obtained from the manufacturer of their suitability in terms of durability and strength (see Annex G); that the clip is fit for the intended use; and that the clip, as fitted, does not adversely affect the performance of the tiles on the roof.

Clips made of aluminium alloy should conform to BS EN 485-1, BS EN 485-2 and BS EN 485-4.

Clips made of stainless steel should conform to BS EN 10048, BS EN 10051, BS EN 10095 and BS EN 10258, and to BS 1554:1990, grade 302, 304, 316, 321 or 347.

Clips made of other alloy types, non-ferrous metals or polymer-based materials may be used provided that they can be demonstrated to be of adequate sustained and fatigue strength (see Annex G) and durability for the intended conditions of use.

4.13.3 Hooks and rivets for slates

4.13.3.1 General

Where hooks or rivets are to be used to secure slates, evidence should be obtained from the manufacturer of their suitability in terms of durability and strength for the purpose for which they are to be used.

A method of test to determine the uplift resistance of a nail hook fixing is given in Annex H (see Annex I for worked examples of wind uplift and fixing calculations for hooks). When fitted, hooks and rivets should not adversely affect the performance of the slates on the roof (see 5.5.3.4.4 and 5.5.3.4.13). Slate manufacturers should confirm that their products are suitable for hook fixing.

NOTE Only double-lap fibre-cement slates fixed with nails use disc headed copper rivets. The rivet holds together the tail, on the centre-line of each slate, to the two slates in the course below, through the gap between them.

4.13.3.2 Hooks

Hooks intended for slating should be formed from stainless steel wire conforming to BS 1554:1990, grades 316 S11 or 316 S19.

Typically, slate hooks attach to the batten by a spike at the upper end, which is driven into the batten or a hook that wraps around the batten. The use of wrap hooks is not recommended. The opposite end should have the form of a curved hook into which the slate fits (see Figure 1). The shank may be straight or crimped, the crimps being in the same plane as the roof slope. Hooks with crimped shanks reduce the capillary rise of water at the perpendicular joints between slates. The peak to trough dimension of the crimp should not exceed 5 mm (Figure 1, dimension T_{hk}).

The slate grip gap in the hook (Figure 1, dimension U_{hk}) should be small enough to hold the slate securely but should not be so small that it would damage the slate. When laid, it should be adequately tight fitting around the slate, due account being taken of different slate thicknesses and variations in thickness for different slate types, to avoid wind rattle and lateral drift.

The hook shank diameter (Figure 1, dimension $\varnothing$) should be not less than 2.70 mm and should not exceed the minimum thickness of the slates being fixed. The hook shank diameter should be of a sufficient size to resist the calculated wind uplift forces (see 5.5.2, 5.5.3.4.13 and Annex H) using the strength value determined by the test method given in Annex H.

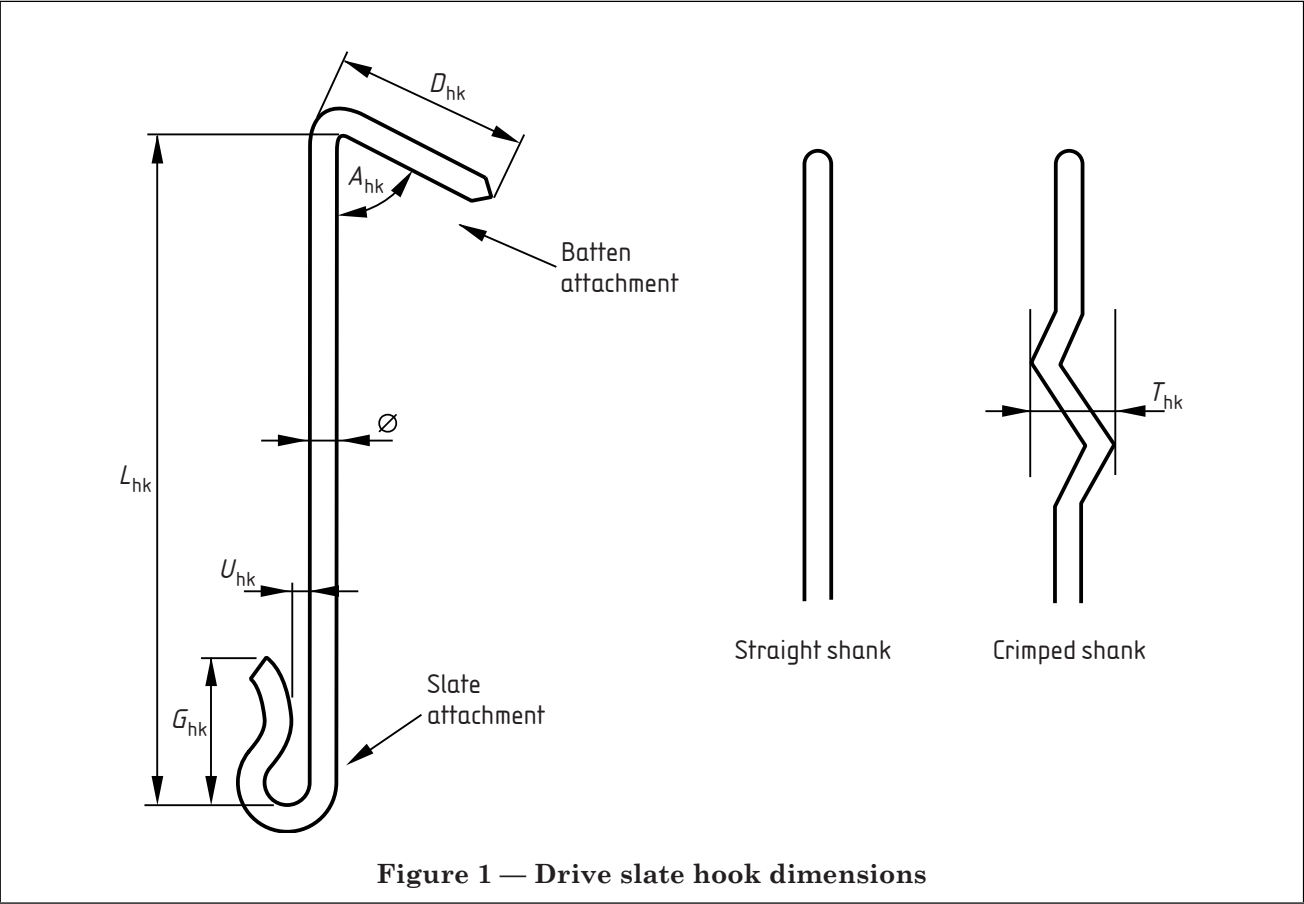
The dimensions of the parts of the hooks should conform to the values given in Table 2 and Figure 1.

NOTE When determining the values of D_{hk} and U_{hk} , account should be taken of the variation of the thickness of the slates in a consignment.

Table 2 — Dimensions of drive slate hooks

Hook part ^a	Dimension
Hook length L_{hk}	Greater than the head-lap + 5.0 mm; and less than the head-lap + 10 mm
Shank diameter $\varnothing$	>2.70 mm; and less than the slate thickness; and not less than the value determined by testing (see Annex H)
Slate grip gap U_{hk}	See 4.13.3.2
Slate grip length G_{hk}	16.0 mm $\pm$ 2.0 mm
Spike length D_{hk}	Slate thickness + 20 mm, or to resist the calculated wind uplift forces (see 5.5.3.4.13 and I.2.5.1) using the strength value determined by the test method given in Annex H, whichever is the larger
Spike angle A_{hk}	(70 $\pm$ 5) $^\circ$
Crimp dimension T_{hk}	<5 mm

^a See Figure 1.



4.14 Flashings and junctions

The sheet materials used for inclined valleys, horizontal gutters, flashings, soakers and saddles should conform to the appropriate material standards and recommendations for minimum thickness given in Table 3.

Table 3 — Flashings and junctions

Material	Material standard	Minimum thickness				
		Horizontal gutters mm	Inclined valleys mm	Flashings mm	Saddles mm	Soakers mm
Lead ^a	BS EN 12588	2.24 (code 5)	1.8 (code 4)	1.8 (code 4)	1.8 (code 4)	1.32 (code 3)
Copper ^b — fully supported	BS EN 1172	0.45 to 0.70 ^c (type ½H)	0.45 to 0.70 ^c (type ½H)	0.55 (type “fully annealed”)	0.55 (type “fully annealed”)	0.55 (type “fully annealed”)
— self-supported	BS EN 1172	—	0.70 (type ½H)	—	—	—
Aluminium and aluminium alloy ^d	BS EN 485-1 BS EN 485-2 BS EN 485-4 BS EN 573	0.70 ^e	0.70 ^e	0.70 ^e	0.70 ^e	0.70 ^e
Zinc and zinc alloy ^f	BS EN 988	0.80	0.80	0.80	0.80	0.80

^a Further advice is available from The Lead Sheet Association.

^b Further advice is available from The Copper Development Association. Refer to BS EN 504 for fully supported roofing products.

^c Depending upon valley width.

^d Further advice is available from The Council for Aluminium in Buildings. Refer to BS EN 507 for fully supported roofing products.

^e Grades 1199, 1080A, 1050A, 1200, 3103 are expected to be suitable if the correct temper is selected for the strength and forming properties required.

^f Further advice is available from The Zinc Development Association. Refer to BS EN 501 for fully supported roofing products.

Proprietary flashing and junction units may be used provided that they can be demonstrated to have adequate strength, water resistance and durability, and not to affect adversely the laying and performance of the roofing products.

4.15 Mortar

Materials for use in mortar should conform to the following recommendations.

a) Cement should conform to BS EN 197-1:2000, class 42.5.

b) Quicklime and hydrated lime should conform to BS 890 or BS 5628-3.

NOTE 1 Hydrated lime is available as a fine powder and can be used to improve workability. It is not frost-resistant and should therefore not be used in vulnerable positions. Hydraulic lime is available as an additive to sand, and may be used for restoration work.

c) Sand should provide a mortar mix that gives adequate bond strength as described in 5.5.3.3.3 when tested in accordance with Annex J.

NOTE 2 BS 1199 and 1200 includes two types of building sand, a type S and a type G which are distinguished by their grading to BS 1199 and 1200, which might overlap. Non-tested material may be used provided that it is of a quality equivalent to that specified in BS 1199 and 1200⁵⁾.

d) Pigment should conform to BS EN 12878. The ratio of pigment to mortar should be no greater than 1 part pigment to 60 parts mortar.

e) Admixtures should conform to BS 4887-1 and to the manufacturer's recommendations. Air entrainers containing plasticizers can improve the frost resistance of the mortar and improve workability.

f) Either the water should be potable, or the specifier should obtain evidence that it does not contain soluble or suspended matter in quantities that could have an adverse affect on the performance of the hardened mortar.

⁵⁾ BS 1199 and 1200 is still current, but has been superseded by BS EN 13139 and is expected to be withdrawn in due course. BS EN 13139 refers to “aggregate” rather than “sand”, and does not specify types S and G.

Mortar should typically consist of the following mixes.

- 1) Cement and sand: volume fractions of 1 part cement to 3 parts sand (type S). Plasticizing admixtures may be added in accordance with the manufacturer's recommendations.
- 2) Cement and sand: volume fractions of 1 part cement to 4 parts sand (type G). Plasticizing admixtures may be added in accordance with the manufacturer's recommendations.
- 3) Adapted site mortar: 8 parts mortar (to BS 5628-3) (1:1:6 cement:hydrated lime:sand) to 1 part cement. This includes pre-mixed mortars where suitability is dependent on usage within the retardation period.
- 4) Cement, hydraulic lime and sand: 6 parts sand (type G or type S) to 1 part cement to 1 part hydraulic lime. This mix is suitable for use where the mass of the component contributes significantly to resist wind uplift (see Note 3).
- 5) Cement, hydrated lime and sand: 1 part cement to 1 part hydrated lime to 6 parts sand (type G or type S). This mix is suitable only as a gap filler and has no significant tensile bond strength.

All admixtures should be used in accordance with the manufacturer's instructions.

Batching of all mortar mixes should be by volume.

NOTE 3 If the use of other mixes is being considered, attention needs to be given to workability of the mix and possible application problems, e.g. the need to avoid unsatisfactory bedding on steep pitches.

NOTE 4 Mortar mixes stronger than those listed above could lead to excessive shrinkage and lower values of tensile adhesion strength when tested in accordance with Annex J.

NOTE 5 Mortars for historical use include sand, hydrated lime and cement mixed with cow hair in the ratio 6 parts sand to 2 parts lime to 1 part cement; sand and medium hydraulic lime in the ratio 3 parts sand to 1 part lime; and sand with hydrated lime and plasticizer in the ratio 4 parts sand to 1 part hydrated lime with plasticizer.

NOTE 6 See NFRC Technical Bulletin 27 [12].

4.16 Other fittings and accessories

4.16.1 Hip irons

Hip irons should be formed from steel strip conforming to BS 1449-1, and should be hot dip galvanized in accordance with BS EN ISO 1461 after cutting, forming and holing. The steel strip should conform to the following dimensions:

- for all roof pitches, hip irons should be 25 mm wide and have a thickness of not less than 5 mm;
- upstands should be of an adequate length to support the hip tile;
- the flat section along the hip rafter should be not less than 400 mm in length and should have two holes to enable it to be fastened with at least two 5 mm diameter screws or nails, coated using any one of the zinc or zinc alloy coating methods specified in BS EN 10230-1.

4.16.2 Rooflights

A range of proprietary translucent slates and tile products or translucent roof/attic windows may be used in the roof system. Rooflights can be manufactured in glass, GRP, PVC or other suitable polymers with or without wire reinforcement.

NOTE 1 There are no British Standards for these products.

NOTE 2 Attention is drawn to the need for durability of strength, light transmission and fire performance of rooflights.

NOTE 3 Refer to prEN 1873 for rooflights with upstands.

4.16.3 Snow guards and boards

Proprietary devices may be used which are fixed directly to the rafters or battens of a tile or slate roof to provide resistance to the movement of snow. These are more common on steeper roof pitches.

The use of snow guards might adversely affect the performance of the roof. Specifiers should seek evidence that this will not be the case and should use snow guards only if such evidence is available.

NOTE 1 There are no British Standards for snow guards and boards.

NOTE 2 Attention is drawn to the need for strength and durability of snow guards and boards.

4.16.4 *Safety hooks*

Safety hooks should conform to BS EN 517. They are fixed directly to the roof or building structure and to which safety ropes or harnesses are attached by roofing or maintenance contractors.

The use of safety hooks might adversely affect the performance of the roof. Specifiers should seek evidence that this will not be the case.

NOTE Attention is drawn to the Construction (Design and Management) (Amendment) Regulations 2000 [10] and BS EN 517.

4.16.5 *Roof walkways*

Roof walkways are sometimes required to provide safe access for roof maintenance or to avoid damage to slates or tiles.

The use of roof walkways might adversely affect the performance of the roof. Specifiers should seek evidence that this will not be the case and should use roof walkways only if such evidence is available.

Permanently fixed walkways should conform to BS EN 516.

NOTE Attention is drawn to the Health and Safety at Work etc. Act 1974 [13].

4.16.6 *Ventilation products*

Ventilation products as fitted should not adversely affect the performance of the roof as laid. Specifiers should seek evidence that this will not be the case and should use ventilation products only if such evidence is available. Where applicable, ventilation products should meet the same performance criteria as the corresponding roof product.

Ventilation products should:

- a) provide an effective weatherproof air path from the external environment into and/or out of the roof space or roof construction zone for the design life of the building;
- b) provide the free air space recommendations given in BS 5250 for the eaves, slate/tile or ridge applications;
- c) prevent access by wildlife, e.g. birds, rodents or large insects;
- d) provide head-laps and side-laps with the surrounding slating in accordance with 5.3.4 and not adversely affect the head-laps and side-laps of the slating.

NOTE 1 Users should pay particular attention to the resistance to wind load, deluge, driving rain and durability performance of ventilation products.

NOTE 2 See also NFRC Technical Bulletin 20 [14].

4.16.7 *Dry roofing products*

Proprietary dry roofing products and systems may be used as an alternative to mortar bedding at verges, ridges, hips and valleys to provide gap closing and mechanical resistance properties.

Dry roofing products as fitted should not adversely affect the performance of the roof as laid. Specifiers should seek evidence that this will not be the case and should use dry roofing products only if such evidence is available.

NOTE 1 There are no British Standards for these products.

NOTE 2 Users should pay particular attention to the resistance to wind load and durability performance of dry roofing products.

4.16.8 *Rainwater products*

Rainwater products should be fitted to the roof at eaves and gullies between roof slopes to drain rainwater and melted snow safely away. Roof drainage and paved areas should be designed in accordance with BS EN 12056-3.

Rainwater products should conform to the relevant British Standards, e.g. BS 4576-1 and BS EN 607 for PVC U. Metal eaves gutters (unlipped) and downpipes should be in accordance with BS EN 612. Cast iron gutters and downpipes should be in accordance with BS 416-1.

4.16.9 Lightning conductors

Lightning conductors should be fitted to roofs of tall buildings in exposed positions or at high altitudes to prevent damage by lightning strikes.

Lightning conductors should conform to BS 6651 and should be mechanically fixed to resist wind loads.

Lightning conductors and their fixings should not adversely affect the rain resistance and watertightness of the roof covering, e.g. they should be located beneath the roofing elements. Specifiers should seek evidence that this will be the case and should use lightning conductors only if such evidence is available.

NOTE The aesthetic appearance of the roof may be taken into account when fitting lightning conductors.

4.16.10 Eaves filler units

Proprietary eaves filler units are devices fitted at the eaves primarily of roofs covered with tiles with deep profiles (greater than a 16 mm sphere). They prevent access by birds and rodents and can also provide an air ventilation function.

The use of eaves filler units might adversely affect the performance of the roof. Specifiers should seek evidence that this will not be the case and should use eaves filler units only if such evidence is available.

NOTE There is no British Standard for eaves filler units.

4.16.11 Undercloak

Where an undercloak is used, it should comprise plain tiles, slates or fibre-cement sheet strip.

It is usually fixed at verges beneath the battens and on top of the underlay, to support the mortar on to which the verge tiles or slates are bedded.

4.16.12 Dentil slips

Where dentil slips are used, they should comprise small rectangular pieces of plain tile, bedded onto the top course of deep profiled single-lap tiles at ridges and hips.

NOTE Dentil slips are typically a full tile or a cut tile, although purpose-made pieces are available. They are used to reduce the amount of mortar required and to prevent shrinkage.

5 Design criteria

5.1 Rain and snow resistance

The UK has a climate where there is a high risk of severe driving rain. Figure 2 details two categories of exposure, based on driving rain penetration data given in BS 8104:1992 and BR 262 [4]. This map should be used when designing buildings up to 12 m ridge height.

NOTE 1 For more detailed guidance, see BS 8104. For buildings above 12 m in height, the influence of increased wind speed can be determined using BS 6399-2.

Roofing products, fittings and accessories, when laid and fixed in a roof, perform in different ways to resist snow and rainwater penetration.

The mechanisms of rainwater ingress with roofing products are varied and can include:

- capillary action and water creep;
- driving rain;
- deluge rain and flooding;
- raindrop bounce;
- surcharging of rainwater on laps on long rafter roofs;
- wind-driven snow.

The extent to which a roofing product will be susceptible to rainwater and snow ingress depends on the design details, pitch, lap, gaps as laid and geometry of the products in relation to the roof and the design, orientation, location, geometry, macroclimate and microclimate affecting the roof.

NOTE 2 At present, the UK does not have a British Standard performance test for rain or snow resistance to assess the pitch and lap performance of pitched roofing products. The recommendations given for rain resistance are based on experience. A European Standard to determine the resistance to driving rain of roof systems with discontinuously laid small elements is currently under development.



5.2 Roof pitch, head-laps and side-laps

NOTE This subclause gives general information about roof pitch, head-laps and side-laps. Recommendations are given in 5.3.

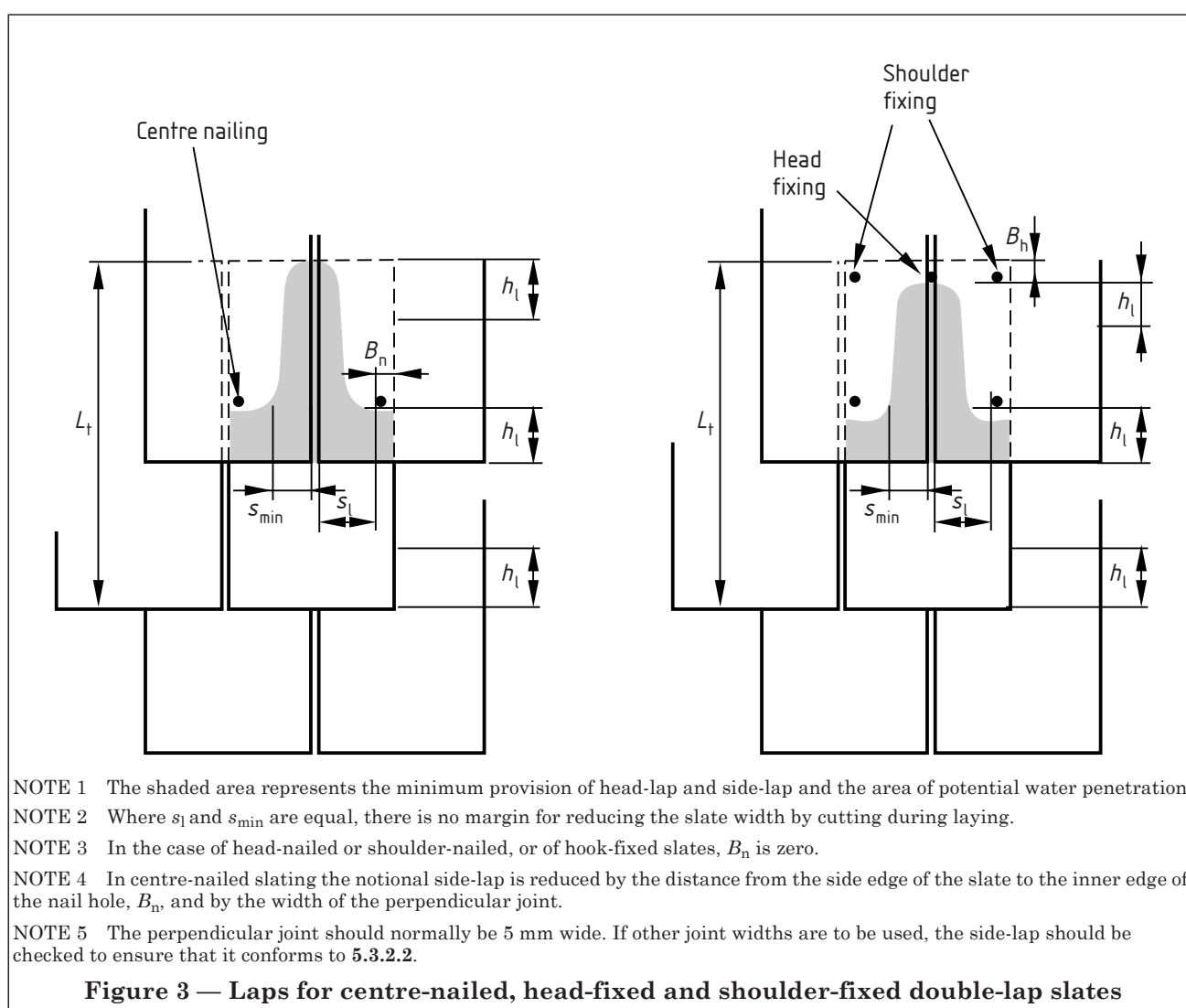
5.2.1 Roof pitches

When calculating head-laps and side-laps, the roof pitch should be taken to be equal to the rafter pitch but see 5.3.4.2. The actual pitch of a slate/tile/shingle when laid is less than the roof pitch.

5.2.2 Head-laps (double-lap)

The head-lap for double-lap products is the distance by which the upper course of the slate/tile/shingle provides a lap with the next but one course below (see 5.4.1 for slates and tiles, 5.4.3 and 5.4.4 for shingles and shakes, and Figure 3 and Figure 4 for slates).

NOTE Certain types of shingle are laid to a triple lap.



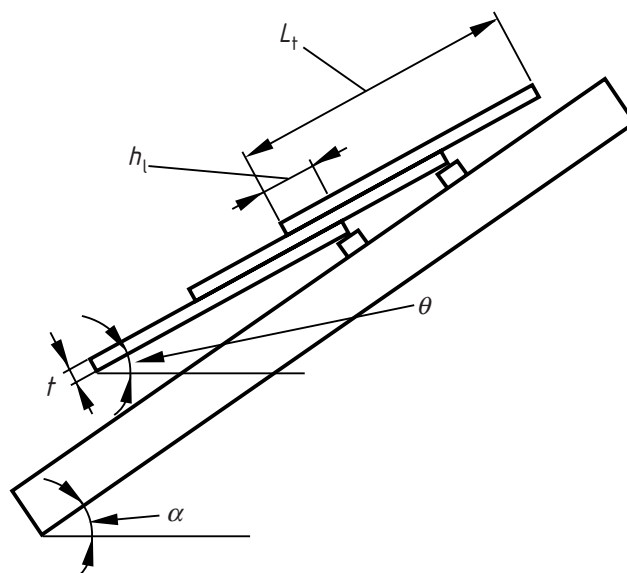


Figure 4 — Pitch of slates in double-lap slating

5.2.3 Head-laps (single-lap)

The head-lap for single-lap tiles (see 5.3.3.1) is the distance by which a course of tiles provides an overlap with the next course below.

NOTE 1 Some single-lap products have a head-lap of fixed dimension resulting from the design of the product.

NOTE 2 Table 4 and Table 5 do not apply to single-lap products.

5.2.4 Side-laps (double-lap)

For double-lap slates and tiles the notional side-lap is the side distance by which the slate or tile overlaps the slate or tile in the next course below (see Figure 3).

The side-lap for plain tiles at 100 mm gauge should be not less than 55 mm.

For double-lap slating (see Figure 3) the side-lap should be the minimum value derived from 5.3.4.2 for the relevant driving rain exposure category. For head-nailed or hook-fixed slates, the side-lap is half of the slate width when the perpendicular joints are placed centrally. For centre-nailed slates, the notional side-lap provided by half of the slate width when the perpendicular joints are placed centrally is reduced by the distance from the side edge of the slate to the inner edge of the nail hole, B_n , plus half the width of the gap between the slates.

5.2.5 Side-laps (single-lap)

The side-lap for single-lap products is the amount by which one tile overlaps the adjacent tile in the same course by way of a side interlock or upstand feature.

NOTE Single-lap interlocking tiles generally have a proprietary side-lock design.

5.2.6 Double-lap slates

5.2.6.1 General

The head-laps and side-laps that should be used in double-lap slating depend on the method of fixing adopted. All double-lap slates may be centre-nailed or hooked. Natural double-lap slates may also be nailed or pegged at the head or the shoulders of the slate.

Fibre-cement double-lap slates greater than 400 mm × 200 mm are fixed with nails and have a rivet at the tail.

5.2.6.2 Centre-nailed slates

Centre-nailed, double-lap slates are fixed with two nails close to the side-edge of the slate and positioned immediately above the head of the slates below (see Figure 3).

NOTE The recommendations for positioning the nail holes in relation to minimum side-lap are given in 5.3.4.2.

In centre-nailed slating, the gauge is the spacing at which battens are fixed to the rafters, trusses or counter-battens to provide the required head-lap. The margin is the exposed length of the slate measured in the same direction as the gauge. Except in random slating with diminishing courses, gauge and margin are the same. The batten gauge G_a , in metres (m), is calculated using equation (1).

$$G_a = \frac{L_t - h_1}{2} \quad (1)$$

5.2.6.3 Hook-fixed slates

Hooked double-lap slates are fixed with a metal hook that engages the tail of the slate in the course above and overlaps the head of the slate in the course below (see 4.13.3.2 and Figure I.5). When hook fixing, additional nail fixings should be used at eaves, ridges and top abutments and, to prevent lateral drift, at verges, hips, valleys and side abutments.

5.2.6.4 Head-fixed slates

Double-lap slates may be fixed centrally at the head of each slate by a single peg or a single nail (see Figure 3). In this case the head-lap is measured from the bottom of the peg or nail hole and not from the top edge of the slate. If it is necessary to place the nail hole further from the head of the slates, the batten gauge should be decreased by a similar amount.

Head-fixed slates do not have the benefit of a long lever arm above the nails or pegs in resisting wind uplift as in centre-nailing. For small slates, the small lever arm might be adequate, but larger slates rely almost entirely on their own mass to resist the uplift force, therefore they should be thick enough to provide the necessary mass (see Annex I, example 5c). Head pegging provides no resistance to wind uplift other than mass resistance unless the slates are head-bedded in mortar and/or the slates are torched.

5.2.6.5 Shoulder-fixed slates

Shoulder-fixed slates are fixed with two nails or pegs near to the top corners of the slates as laid, outside the area of water spread (see Figure 3). In this case the head-lap is measured from the top edge of the slate. The fixing holes should normally be placed between 20 mm and 25 mm from the head of the slate. Because this fixing dimension B_h is treated as being zero in shoulder-fixing, it is not necessary to take it into account when calculating head-laps.

Shoulder-fixed slates do not have the benefit of a long lever arm in resisting wind uplift as in centre-nailing. For small slates, the small lever arm might be adequate, but larger slates rely almost entirely on their own mass to resist the uplift force, therefore they should be thick enough to provide the necessary mass (see Annex I, example 5c). Head pegging provides no resistance to wind uplift unless the slates are head-bedded in mortar and/or the slates are torched.

5.2.6.6 Fixing slates to boards

Slates may be nailed to continuous softwood boarding, e.g. where curved roof features are to be slated.

In Scottish practice it is common to nail slates to softwood sarking boards using a combination of shoulder-nailing and centre-nailing to resist wind uplift.

5.3 Recommendations for minimum pitch, head-laps and side-laps for roofs (less than 75°)

5.3.1 General

The recommendations for minimum pitches and laps for slate and tile products apply to normal situations. Generally, the recommendations for slates apply to rafter lengths of not more than 9 m in driving rain exposures of less than 56 l/m² per spell and 6 m in driving rain exposures of 56 l/m² per spell or greater (see 5.3.4). Also, the specifier should take account of any abnormal conditions that might apply, and might need to specify greater values than the recommended minima. If it is necessary to use pitches lower than the recommended minima, special precautions should be taken (see 5.3.9).

Where abnormal weather conditions might be expected, e.g. on elevated sites, near to the coast, in localities where heavy snow falls are commonly experienced or in conditions of severe exposure, the following recommendations for pitches and laps will not always ensure full protection from the weather. In such conditions, the specifier using generic products should seek guidance from a competent person who is conversant with local conditions and any special precautions that should be taken into account in designing the roof covering.

In special forms of slating, such as for random slate or conical roofs where the slate widths are variable, the minimum head-laps and side-laps should be calculated in accordance with 5.3.4. For conical roofs where the slates are tapered in their length, the applicable width is the width at the head of the slate.

Where proprietary tile and artificial slate products are to be specified, the manufacturer's recommendations should be followed. Additionally, the specifier should obtain evidence that the performance of these products and recommendations have been proven to be satisfactory, by relevant experience in use or relevant test data based on the conditions and methods of use in equivalent and appropriate climatic conditions.

NOTE A European Standard to determine the resistance to driving rain of roof systems with discontinuously laid small elements is currently under development.

5.3.2 Double-lap clay and concrete plain tiles

5.3.2.1 Head-lap

Head-lap should be not less than 65 mm and should not exceed one-third of the length of the tile. For feature and ornamental tiles, the shape of the tail should be considered when the head-lap is specified and if necessary the head-lap should be increased.

NOTE The design of some products limits the maximum head-lap.

5.3.2.2 Side-lap

Side-lap should be not less than one-third of the width of a plain tile. Special and purpose-made hip and valley tiles should, where practicable, provide for side-laps not less than one-third of the width of a plain tile. Where this is not practicable, soakers should be used.

NOTE Special hip and valley tiles that do not conform to the recommendations for side-lap might be suitable in practice. Manufacturers of such products should produce evidence of satisfactory long-term performance of the product at the intended roof pitches, head-laps and side-laps.

5.3.2.3 Roof pitch

Plain tiles should be laid at rafter pitches not less than 35°. Clay tiles that do not meet the dimensional and geometric requirements given in BS EN 1304 should be laid at pitches not less than 40°.

5.3.3 Single-lap clay and concrete tiles (interlocking)

5.3.3.1 Head-lap

The minimum head-lap for variable gauge tiles without a headlock should be not less than 75 mm. The head-lap properties for products that have features on the top and underside surface and/or sidelock are determined by the design.

NOTE A fixed gauge tile can have the maximum head-lap defined by design features on the top and underside surface and/or sidelock.

5.3.3.2 Side-lap

The side-lap of single-lap clay or concrete tiles is fixed by the side-lock design.

5.3.3.3 Roof pitch

In general, roof pitches should be not less than 30°. Proprietary tile designs that have effective anti-capillary head-lap features, side-lock features and are close-fitting as laid, may be used below 30°. Manufacturers of tiles, fittings or accessories should produce evidence of satisfactory prolonged and extensive use of their products at the roof pitches, head-laps and side-laps for which they are intended to be used. Examples include: evidence that products have been shown to be satisfactory for not less than 15 years in the location of intended use; or evidence from an appropriate test method that can be directly correlated with the recommended conditions of use.

NOTE Refer to Figure 2 to establish exposure zones relative to the risk of driving rain.

5.3.4 Double-lap fibre-cement and natural slates, nail-fixed or hook-fixed

NOTE The recommendations for laps given in 5.3.4 might not be adequate at rafter pitches of 30° or less under the following conditions:

- in driving rain exposures of less than 56.5 l/m² per spell, for rafter lengths greater than 9 m;
- in driving rain exposures of 56.5 l/m² per spell or greater, for rafter lengths greater than 6 m.

In these circumstances, consideration should be given at the design stage to the provision of a functional sub-roof below the slating, which should be capable of collecting any water and discharging it from the building, or to the incorporation of intermediate gutters in the roof slope.

5.3.4.1 Head-lap

The head-lap should be determined from the length and width of the slate, the driving rain exposure category of the site, and the roof pitch. For pitches between 20° and 45° the recommended minimum head-lap, *h*₁, in metres (m), can be calculated using equation (2).

$$h_1 = \frac{c}{\sin \alpha}$$
 (2)

NOTE Categories of exposure to driving rain are shown in Figure 2. The corresponding values of *c* are shown in Table 4.

Table 4 — Values of *c* for head-lap calculations for double-lap fibre-cement and natural slates, nail-fixed or hook-fixed

Driving rain exposure category	Corresponding value of <i>c</i>
<56.5 l/m ² per spell	0.0385
≥56.5 l/m ² per spell	0.0490

For pitches greater than 45° and less than 75°, the head-lap should be not less than 54 mm for driving rain exposures of less than 56.5 l/m² per spell and not less than 69 mm for driving rain exposures of 56.5 l/m² per spell or greater. Head-laps greater than one-third of the slate length should not be used except in specialized traditional forms of roofing such as scantle slating.

5.3.4.2 Side-lap

The nature of single-sized, double-lap slating ensures that a notional half width of slate overlaps the slate below. The suitability of any width of slate for a given roof pitch and driving rain exposure category (see Figure 2) should be confirmed by ensuring that it provides a side-lap not less than the minimum value, *s*_{min}, calculated using equation (3)⁶⁾ and the head-lap derived from Table 5. Interpolation for other pitches is permitted.

$$s_{min} = \left(\frac{L_t - h_1}{2} \right) E_1$$
 (3)

⁶⁾ Factor *E*₁ is a multiplier applied to the gauge/margin of the slates to calculate the side-lap, and is determined from the pitch of the roof and driving rain exposure category in Table 5. Longer gauges/margins can require wider side-laps.

Table 5 — Minimum head-laps and E_l factors for double-lap fibre-cement and natural slates, pegged, nailed or hook-fixed^{a b c d e}

Minimum roof pitch ^{f g} degrees (°)	Driving rain exposure			
	<56.5 l/m ² per spell		≥56.5 l/m ² per spell	
	Minimum head-lap ^h mm	Value of factor $E_l^{i j}$	Minimum head-lap ^h mm	Value of factor $E_l^{j k}$
≥45, <75	54	0.395	69	0.465
40	60	0.400	76	0.470
35	67	0.410	86	0.480
30	77	0.425	98	0.495
27.5	83	0.440	106	0.508
25	91	0.470	116	0.530
22.5	101	0.530	128	0.570
20	113	0.600	143	0.650

^a For triple-lap shingles or shakes, refer to the manufacturer's guidance.

^b Hooks should not be used at pitches less than 25°.

^c Crimped hooks should be used at pitches of 30° or less.

^d See 5.3.4.3 for the effect of slate thickness on slate pitch.

^e For all types of double-lap slating, the recommendations for head-laps, side-laps and roof pitches apply. If manufacturers recommend head-laps and side-laps other than those calculated from this table, they should provide evidence of satisfactory performance.

^f Interpolation for other pitches is permitted.

^g The minimum roof pitch for all double-lap slating is 20°.

^h Head-laps greater than one-third the slate length should not be used except in specialized traditional forms of roofing such as scantle slating.

ⁱ For <56.5 l/m² per spell driving rain exposure:

- the side-lap should under no circumstances be less than 54 mm;
- slates 450 mm long or less should not be used at pitches of 27.5° or less.

When re-holing slates, care should be taken to ensure that the position of the new holes meets the recommendations given in 5.3.4.

^j The minimum side-laps recommended in footnotes i and k are intended to provide adequate resistance to water penetration. Recommendations for minimum width to provide adequate strength at verges are given in 6.7.2.

^k For ≥56.5 l/m² per spell driving rain exposure:

- the side-lap should under no circumstances be less than 69 mm;
- slates ≤500 mm and >460 mm long should not be used at pitches less than 22.5°;
- slates ≤460 mm and >450 mm long should not be used at pitches of 22.5° or less;
- slates ≤450 mm long should not be used at pitches of 27.5° or less.

The minimum slate width, $b_{\min}$, should be calculated using equation (4).

$$b_{\min} = 2(s_{\min} + B_n) \quad (4)$$

The distance from the side edge of the slate to the inner edge of the nail hole, B_n (see Figure 3), may range from 18 mm to 30 mm depending on the slate's properties (artificial or natural, thin or thick). The value used for the calculation of minimum side-lap, and hence the minimum slate width, should be based on the slate product used and the manufacturer's recommendations. In practice, the nail hole position will vary and therefore the maximum value should be used when calculating the minimum side-lap. Where it is necessary to place the nail holes further from the side edge of the slate, the distance should not compromise the minimum side-lap recommendations.

The nail holing gauge, h_g , for centre-nailed slates should be calculated using equation (5).

$$h_g = G_a + h_l + 0.008 \text{ to } 0.015 \quad (5)$$

Where it is necessary to trim slates around roof details such as chimneys, rooflights and slate vents, it is good practice to design the roof on the basis of slates wider than the minimum value calculated using equation (4). Irrespective of this provision, additional extra-wide slates might be necessary to maintain adequate side-laps at abutments and hips.

These recommendations apply to roofs that are constructed with perpendicular joints not exceeding 5 mm wide. If the joints are wider then the effective side-lap will be reduced by half the difference and this should be taken into account when calculating the side-lap.

5.3.4.3 Roof pitch

The recommended roof pitch and minimum head-laps for double-lap, natural, fibre-cement and other artificial slates, nail-fixed or hook-fixed, should be obtained from Table 4 and Table 5. The roof pitch should be not less than 20°.

Where abnormal conditions are expected, e.g. on elevated sites, near to the coast, or where high snow or rainfall is experienced, the values for driving rain exposures of 56.5 l/m² per spell or greater in Table 5 should be used to obtain the recommended head-lap and roof pitch. For other situations, the values for driving rain exposures of less than 56.5 l/m² per spell should be used. Consideration should also be given to the influence of the height of tall buildings on driving rain exposure (see 5.1).

Where the applicable driving rain exposure category derived from Figure 2 is uncertain, e.g. at the boundary of the two driving rain categories, more precise data is available in BS 8104. If this guidance does not resolve the issue, a driving rain category of 56.5 l/m² per spell or greater should be used.

The actual pitch at which slates lie is influenced by their length, head-lap and thickness (see Figure 4). Where the thickness of natural slates reduces their pitch by 3° or more, the next lower rafter pitch should be selected when determining the recommended head-lap and slate width using Table 4 or Table 5.

The pitch of the slates, in degrees (°), may be calculated using equation (6).

$$\theta = \alpha - \left[\tan^{-1} \left(\frac{2t}{L_t - h_1} \right) \right] \quad (6)$$

Generally, water should not be discharged directly onto one slope from another or from rainwater pipes. Where this is unavoidable, the combined length and area of the upper and lower pitches should be used to determine the slate laps and the sizes of gutters and rainwater pipes.

5.3.5 Bitumen shingles

Bitumen shingles, which are proprietary products of various designs, may be laid and fixed with or without an adhesive section in the head-lap area.

Under normal circumstances, the head-lap should be not less than 200 mm and the side-lap should be not less than half the width of the tab (see 5.3.9).

The roof pitch should be in accordance with the manufacturer's recommendations, based on relevant experience in use or relevant test data reflecting appropriate climatic conditions.

5.3.6 Wooden shingles and shakes

Wooden shingles and shakes, which are products of various designs, may be laid and fixed with or without a roofing underlay.

The head-lap should be determined from the length and thickness of the shingle or shake, the driving rain exposure category, the roof pitch and the surface characteristics of the product. Under normal circumstances, the side-lap should be not less than 40 mm (see 5.3.9).

The roof pitch should be in accordance with the manufacturer's recommendations, based on relevant experience in use or relevant test data reflecting appropriate climatic conditions.

5.3.7 Metal tiles

Metal tiles, which are proprietary products of various designs, should be laid in accordance with the manufacturer's recommendations, based on relevant experience in use or relevant test data reflecting appropriate climatic conditions.

The head-lap should be fixed by the design features of the head and tail. The side-lap should be fixed by the design features, which are typically related to the centres of the profiled or shaped features.

The roof pitch should be in accordance with the manufacturer's recommendations, based on relevant experience in use or relevant test data reflecting appropriate climatic conditions.

5.3.8 Other tiles and slates

Manufacturers of other proprietary tiles and slates, including composite, resin-filled or bonded and lightweight products, etc., of various designs, should produce evidence of satisfactory performance at the roof pitches, head-laps and side-laps for which the products are intended to be used, based on:

- a) prolonged and extensive use of the products (e.g. evidence that products have been shown to be satisfactory for not less than 15 years in relevant climatic conditions); or
- b) results of a test method that can be directly correlated with the recommended conditions of use.

5.3.9 Application of roof products at less than the recommended roof pitch, head-lap or side-lap

There are design situations where it would be difficult to avoid using a roofing product, fitting or accessory at less than the recommended roof pitch, head-lap or side-lap. These situations can include, for example, a lean-to on an existing building where a window, cavity tray line or boundary restricts the roof pitch. In these situations, it is to be expected that the roof covering might experience rain or snow penetration.

NOTE 1 Roof product manufacturers' guarantees might not apply in these situations.

A roof designed below the recommended roof pitch should have a functional weatherproof sub-roof system to remove any rainwater ingress safely to the eaves gutter. If proprietary sub-roof systems are used, they should meet the recommendations for strength, water resistance, nail tear resistance, water vapour resistance (where required) and durability given in this British Standard. The sub-roof system might adversely affect the laying and performance of roofing products. Specifiers should seek evidence that this will not be the case and should use sub-roof systems only if such evidence is available.

NOTE 2 Users are advised to refer to UKAS-accredited third-party certificates and manufacturers' technical data that are relevant to UK conditions of use.

5.4 Recommendations for minimum head-laps, side-laps and overlaps for walls (75° pitch and above)

5.4.1 Double-lap clay and concrete plain tiles, fibre-cement slates and natural slates

The head-lap should be:

- not less than 37.5 mm for double-lapped clay and concrete plain tiles;
- not less than 44.5 mm for double-lapped slating.

For side-laps, refer to 5.3.2.2 and 5.3.4.2.

5.4.2 Single-lap clay and interlocking concrete tiles

The head-lap is determined by design features on the top surface at the head of the tile and/or features on the under surface at the tail of the tile. For variable products the head-lap should be not less than 35 mm below the nail hole.

The side-lap is determined by the side-lock design.

5.4.3 Bitumen shingles

The overlap should be not less than 200 mm. The side-lap should be not less than half the width of the tab.

5.4.4 Wooden shingles and shakes

The head-lap should be determined from the length and thickness of the shingle or shake, the exposure category, the roof pitch and surface characteristics of the product.

The side-lap should be not less than 38 mm.

5.4.5 Metal tiles

The head-lap is determined by the design of the head and tail of the metal tile.

The side-lap is determined by the design of the metal tile, which is typically related to the centres of the corrugation and shaped features.

5.4.6 Other tiles and slates

Manufacturers of other proprietary tiles and slates, including composite, resin-filled or bonded and lightweight products, etc., of various designs, should produce evidence of satisfactory performance at the roof pitches, head-laps and side-laps for which the products are intended to be used, based on:

- a) prolonged and extensive use of the products (e.g. evidence that products have been shown to be satisfactory for not less than 15 years in relevant climatic conditions); or
- b) results of a test method that can be directly correlated with the recommended conditions of use.

5.5 Structural stability

5.5.1 Dead loads and imposed loads

Dead loads and imposed loads should be calculated in accordance with the recommendations given in BS 6399-1 and BS 6399-3.

5.5.2 Wind loads

5.5.2.1 General

The effective wind speed, V_e , and the dynamic pressure of the wind, q_s , appropriate to the location, altitude and other topographical conditions in the United Kingdom, should be calculated in accordance with the standard method described in BS 6399-2, taking the size effect factor, C_a , as 1.0 for slating/tiling.

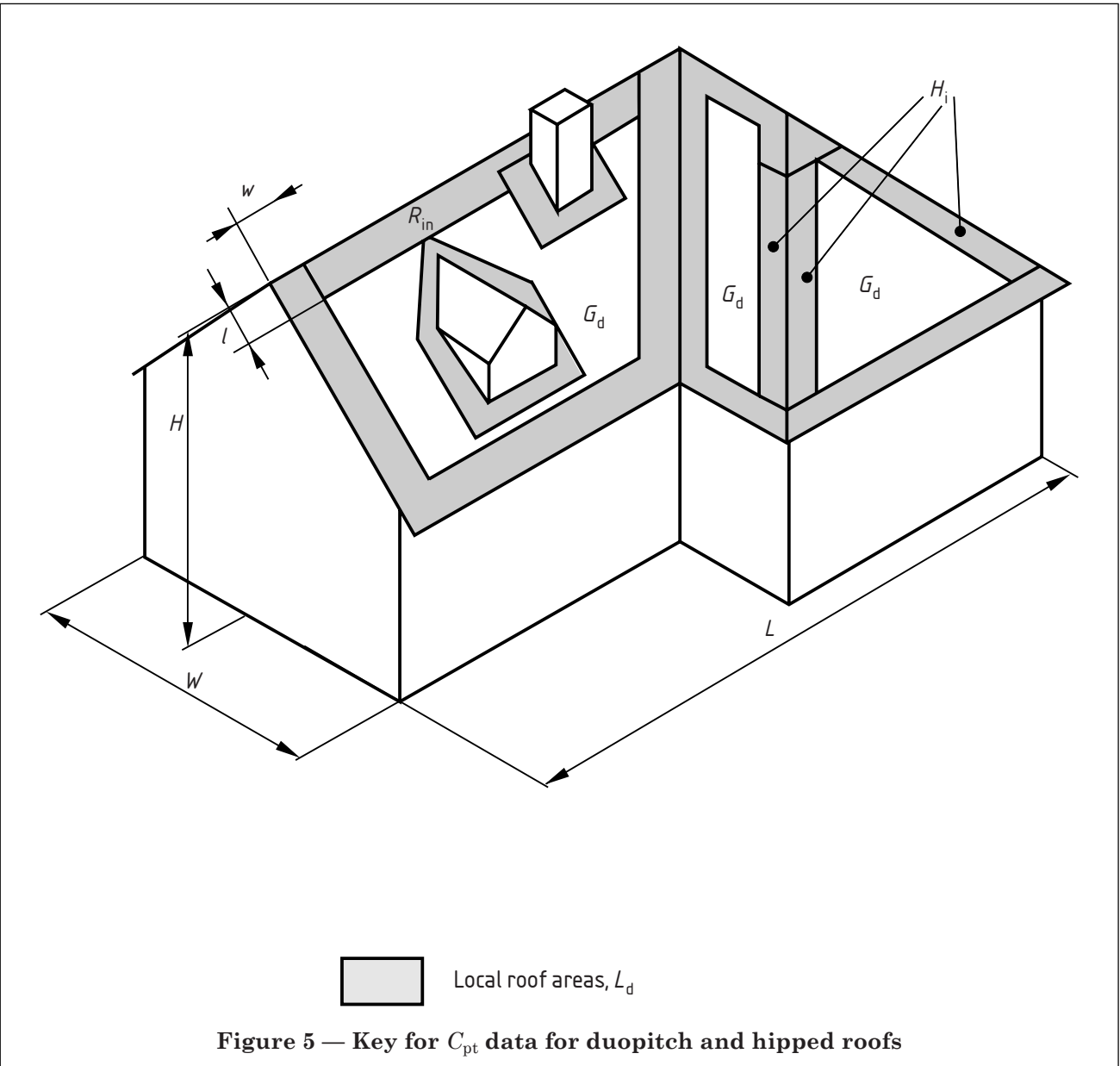
The appropriate pressure difference coefficient, C_{pt} , depends on the roof geometry and building and should be obtained from Table 6, Figure 5 and Figure 6. Alternatively, for more complex roof shapes, appropriate C_{pe} values may be obtained from the more precise data given in BS 6399-2 and these should be used in conjunction with values for uplift pressure reduction factor, R , from Annex K.

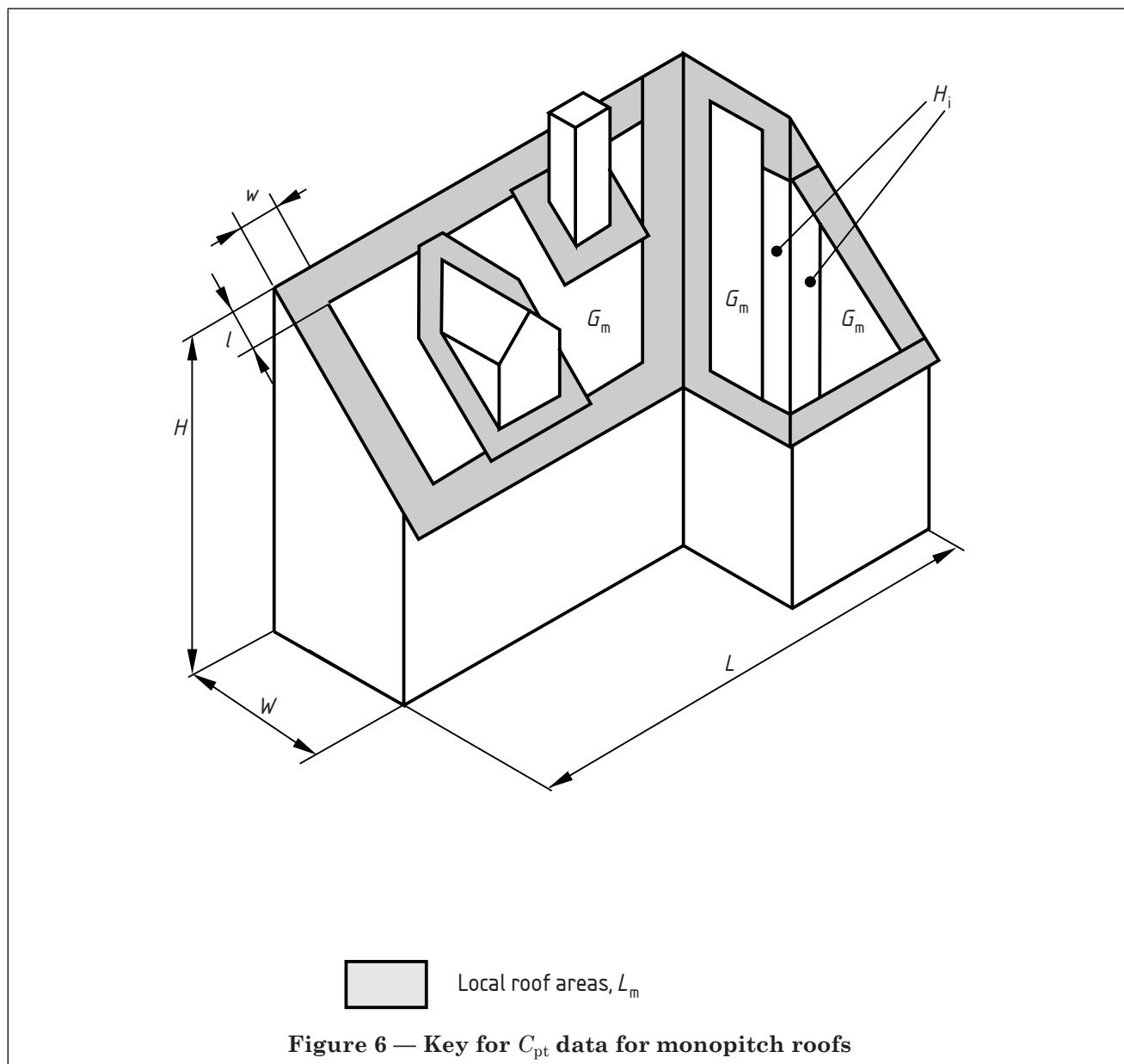
The wind uplift load on discontinuously laid small element roofing products with unsealed laps should be derived taking into account air permeability through the side-laps and end-laps (see 5.5.2.3.1, 5.5.2.3.2, 5.5.2.3.3, 5.5.2.4 and 5.5.2.5).

NOTE Attention is drawn to areas of high local wind uplift occurring near roof edges and around obstructions such as chimneys, small dormers and other similar projections above the roof surface.

Table 6 — Pressure difference coefficients (C_{pt}) for duopitch, hipped, and monopitch roofs of clad rectangular buildings

Roof pitch ^a degrees (°)	Pressure difference coefficient, C_{pt}				
	Duopitch and hipped roofs			Monopitch roofs	
	General roof areas, G_d	Inner ridge and hip local roof areas, R_{in} and H_i	Other local roof areas and valleys, L_d	General roof areas, G_m	All local roof areas and valleys, L_m
12.5	−0.14	−0.16	−0.21	−0.14	−0.21
15	−0.14	−0.15	−0.20	−0.14	−0.21
17.5	−0.13	−0.15	−0.19	−0.14	−0.21
20	−0.12	−0.14	−0.18	−0.14	−0.21
22.5	−0.11	−0.14	−0.17	−0.14	−0.21
25	−0.11	−0.14	−0.16	−0.14	−0.21
27.5	−0.11	−0.14	−0.15	−0.14	−0.21
30	−0.11	−0.14	−0.14	−0.14	−0.21
35 to 75	−0.11	−0.13	−0.13	−0.14	−0.21
NOTE 1 Values of C_{pt} for other, more complex, roof shapes can be obtained from the product of C_{pe} data from BS 6399-2 and values of R from Table K.1.					
NOTE 2 The width and length of the local areas are given by: — $w = 0.2H$ or $0.1W$, whichever is the lesser; — $l = 0.2H$ or $0.1L$, whichever is the lesser.					
NOTE 3 Roof abutments (side edge, and top edge) should be treated as local roof areas (see Figure 5 and Figure 6).					
^a Slates and tiles covered by this British Standard cannot necessarily be used at all of the pitches listed.					





5.5.2.2 Obstructions

Obstructions are roof features, such as chimneys, roof windows etc., that extend either 300 mm or more above, or 300 mm or more below, the plane of the roof, i.e. $Z \geq 300$ mm or $Z \leq -300$ mm.

For obstructions where Z is between 100 mm and 299 mm above or below the roof surface, the surrounding roofing elements should be treated as “perimeter” slates/tiles. Obstructions of less than 100 mm above or below the roof surface may be ignored.

“Perimeter” roof covering elements are those single elements that abut any discontinuity in the plane of the roof, including the roof’s edges. They should be mechanically fixed to the minimum recommendations of 5.5.3.4.

NOTE “Perimeter” roof covering elements are differentiated from “local” areas, which are roof areas that extend over a defined width of the roof.

The distances around obstructions are given by equations (7) to (10). Dimension x should be calculated using equation (7) or equation (8), whichever gives the lesser value, and dimension y should be calculated using equation (9) or equation (10), whichever gives the lesser value.

$$x = \frac{1}{2} \sqrt{(X^2 + Z^2)} \quad (7)$$

$$x = \frac{1}{2} \sqrt{(X^2 + Y^2)} \quad (8)$$

$$y = \frac{1}{2} \sqrt{(Y^2 + Z^2)} \quad (9)$$

$$y = \frac{1}{2} \sqrt{(X^2 + Y^2)} \quad (10)$$

Dimensions x and y are shown in Figure 7.

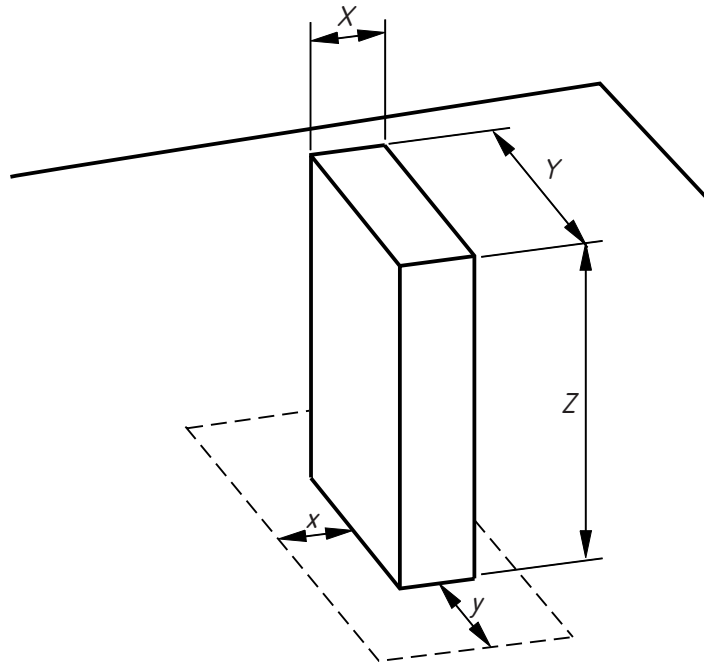


Figure 7 — Distances around obstructions

5.5.2.3 Wind loads on slates and tiles with unsealed laps (excluding ridges, hips and valleys)

NOTE These wind loads act on the centre of the exposed area of the roofing element and in a direction perpendicular to it.

5.5.2.3.1 Roof coverings that do not overhang either the verge or eaves by more than 50 mm

For roof coverings that do not overhang either the verge or the eaves by more than 50 mm, the wind uplift force, F_t , should be calculated using equation (11).

$$F_t = q_s \times C_{pt} \times A_t \times D \times S \quad (11)$$

where

$$A_t = B \times G_a$$

$$q_s = 0.613 V_e^2$$

$$D = (\log_{10} K) - 1$$

Values of D should be either obtained from Table 7 or obtained by test in accordance with Annex L.

Values of S should be obtained from Table 8.

Table 7 — Values of air permeability factor D for certain roof covering types laid with unsealed head-laps and side-laps

Roof covering type	Value of factor D^a
Double-lap slates ($K = 32\,000$)	3.51
Plain tiles ($K = 5\,000$)	2.70
Single-lap tiles ($K = 30\,000$)	3.48
Other types	
— without test data	4.70
— derived from test data	$\geq 2.70^b$

^a Values of D given in this table for double-lap slates, plain and single-lap tiles commonly available in the UK, were obtained by test (and rounded) in accordance with Annex L.

^b For other types of roof covering, the value of D should be 2.70, or the value obtained from Annex L, whichever is the greater.

Table 8 — Values of roof substrate shielding factor S for calculating the wind uplift loads on roof coverings laid with unsealed head-laps and side-laps

Roof construction	Value of factor S
On underlay or board sarking	1.00
On counter-battens of depth d , in millimetres (mm), on underlay or board sarking	the lesser of $1 + (d/200)$, or 1.25
Without underlay or board sarking	— ^a

^a Use equation (19), i.e. treat as 5.5.2.6.

5.5.2.3.2 Roof coverings that overhang the eaves by more than 50 mm

For roof coverings that overhang the eaves by more than 50 mm (see Figure 8 and Figure 9), there are two loads acting simultaneously, F_{oe} and F_{te} . F_{oe} acts on the overhanging part and should be calculated using equation (12), and F_{te} acts on the part protected by the underlay and should be calculated using equation (13).

$$F_{oe} = q_s \times \left[\left(\frac{C_{pt}}{R} \right) - 0.8 \right] \times A_{oe} \quad (12)$$

where

$$A_{oe} = B(L_o - 0.05)$$

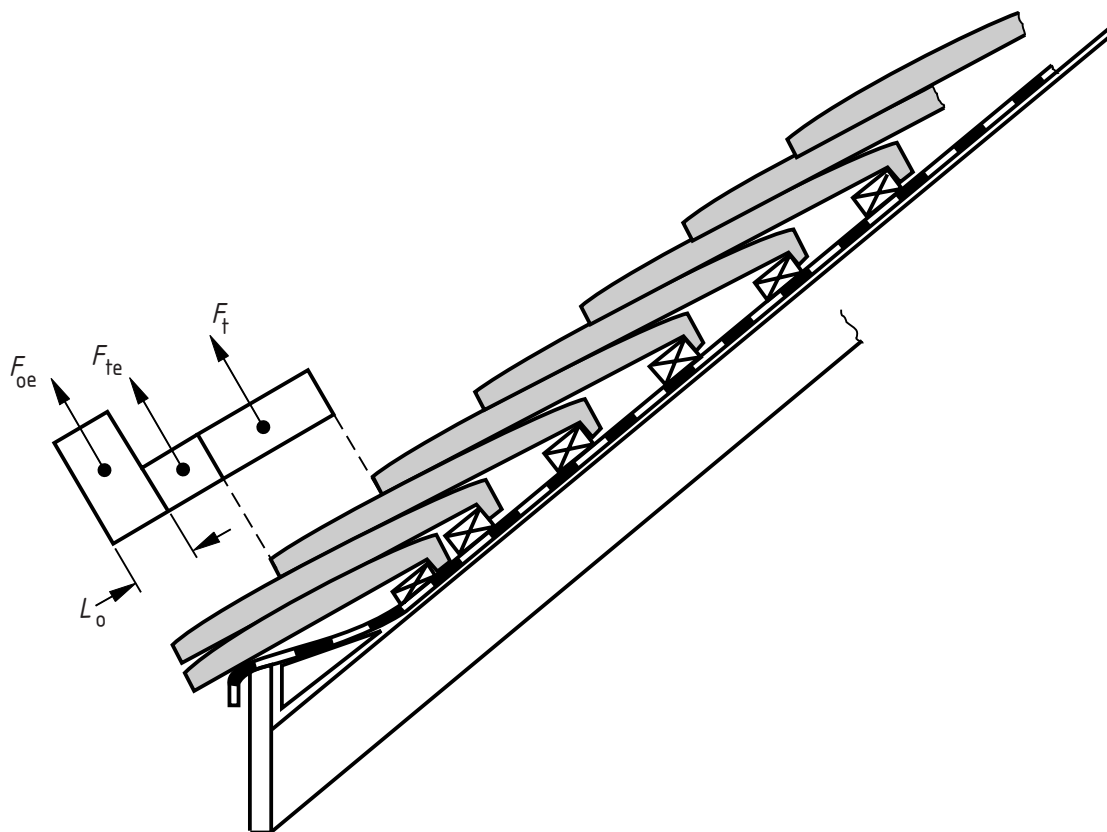
$$F_{te} = q_s \times C_{pt} \times A_{te} \times D \times S \quad (13)$$

where

$$A_{te} = B(G_a - L_o + 0.05)$$

The total load on the tile should be calculated from the sum of the overturning moments from the forces F_{oe} and F_{te} .





NOTE Equation (12) and equation (13) should be used when the eaves overhang exceeds 50 mm.

The total load on the overhanging tile is $F_{oe} + F_{te}$.

Figure 9 — Wind uplift loading on double-lap slates or tiles, including where the eaves overhang exceeds 50 mm

5.5.2.3.3 Roof coverings that overhang the verges by more than 50 mm

For roof coverings that overhang the verges by more than 50 mm (see Figure 10), there are two loads acting simultaneously, F_{ov} and F_{tv} . F_{ov} acts on the overhanging part and should be calculated using equation (14), and F_{tv} acts on the part protected by the underlay and should be calculated using equation (15).

$$F_{ov} = q_s \times \left[\left(\frac{C_{pt}}{R} \right) - 0.8 \right] \times A_{ov} \quad (14)$$

where

$$A_{ov} = G_a(B_o - 0.05)$$

$$F_{tv} = q_s \times C_{pt} \times A_{tv} \times D \times S \quad (15)$$

where

$$A_{tv} = G_a(B - B_o + 0.05)$$

The total load on the tile or slate should be calculated from the sum of the overturning moments from the forces F_{ov} and F_{tv} .