

BS 5534:2014+A2:2018



BSI Standards Publication

Slating and tiling for pitched roofs and vertical cladding — Code of practice



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This document comprises a front cover, and inside front cover, pages i to vi, pages 1 to 166, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 August 2014. It was prepared by Subcommittee B/542/1, *Slating and tiling*, under the authority of Technical Committee B/542, *Roofing and cladding products for discontinuous laying*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

BS 5534:2014+A1:2015 superseded BS 5534:2014, which was withdrawn.

BS 5534:2014+A2:2018 supersedes BS 5534:2014+A1:2015, which will be withdrawn on 1 July 2018.

Relationship with other publications

This British Standard is intended to be read in conjunction with [BS 5250](#), [BS 9250](#) and [BS 8000-6](#).

Information about this document

Text introduced or altered by Amendments No. 1 and No. 2 is indicated in the text by tags A1 A1 and A2 A2. Minor editorial changes are not tagged.

This British Standard was first published as [BS 5534-1](#) in April 1978 and was updated in 1990, 1997 and 2003. [BS 5534-2](#) was first published in November 1986 and was withdrawn on publication of [BS 5534-1:1997](#), by which it was superseded.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 is a full revision of the standard, and includes a complete re-structuring intended to make the standard more usable in addition to introducing the following principal changes.

- a) [Subclause 5.2](#) and [Annex H](#), which deal with structural stability, have been revised to reflect new knowledge and experience on wind loads and uplift resistances of the roof covering and underlay, expressed in terms of the relevant Eurocodes for basis of structural design, enhanced safety factors, loads and resistances.
- b) The worked examples of wind uplift and fixing calculations given in [Annex K](#) have been updated.
- c) Wind uplift resistance of self-supporting underlays has been included. A pressure test ([Annex A](#)) has been introduced to determine the wind uplift resistance of underlays in order to determine their scope of application and classification.
- d) Clause 6, which deals with application and design details has been revised, including references to workmanship, which are now covered in the 2013 revision of BS 8000-6.
- e) Reliance on the tensile strength of mortar bedding to resist wind uplift has been withdrawn.

Updated information relating to the preservative treatment of timber battens has been contributed by the Wood Protection Association (www.wood-protection.org)¹.

Amendment No.2 incorporates the following changes:

- Clarification of the scope of the standard in relation to its intended use for old and heritage roofs
- Additions of new terms and definitions for an air permeable underlay, and continuous and discontinuous ceilings
- Updated recommendations on the application of roofing underlays and their testing and classification for wind uplift resistance (Annex A)
- Updated Annex I and method of test for tile clip strength including amendments to Figures I.1, I.2 and I.5
- Minor corrections and updated references to new standards and publications, including BS 8612, *Dry-fixed ridge, hip, and verge systems for slating and tiling – Specification*.

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.

Use of this document

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.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

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

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

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

In the case of “sulfur” (and its derivatives), the International Union of Pure and Applied Chemistry (IUPAC) spelling is used.

Contractual and legal considerations

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

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

Particular attention is drawn to the Control of Substances Hazardous to Health Regulations 2002 [1].

¹ Last accessed 26 August 2014.

1 Scope

A2 This British Standard gives recommendations primarily intended for the design, performance and installation of new build pitched roofs, including vertical cladding, and for normal re-roofing work, including repairs, using slates, tiles, shingles and shakes and their associated components. This British Standard does not cover the structural design of the roof.

The recommendations contained in this British Standard might not be appropriate for the re-slating or re-tiling of some old roofs, particularly where traditional and/or reclaimed materials are used. Users intending to adopt any of these recommendations for old roofs, and especially for historically or architecturally important buildings, are advised to consult with the local planning authority or an appropriate conservation organization to check their suitability.

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

NOTE 1 Recommendations for workmanship, repair and maintenance are given in [BS 8000-0](#) and [BS 8000-6](#).

*NOTE 2 A Code of Practice for slating historic buildings is in preparation by Historic England². **A2***

2 Normative references

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

Standards publications

[BS 416-1](#), *Discharge and ventilating pipes and fittings, sand-cast or spun in cast iron — Part 1: Specification for spigot and socket systems*

[BS 1202-2](#), *Specification for nails — Part 2: Copper nails*

[BS 1202-3](#), *Specification for nails — Part 3: Aluminium nails*

[BS 2000-49](#), (BS EN 1426), *Bitumen and bituminous binders — Part 49: Determination of needle penetration*

[BS 2000-58](#), (BS EN 1427), *Bitumen and bituminous binders — Part 58: Determination of the softening point — Ring and ball method*

[BS 4841-5](#), *Rigid polyisocyanurate (PIR) and polyurethane (PUR) products for building end-use applications — Part 5: Specification for laminated boards (roofboards) with auto-adhesively or separately bonded facings for use as thermal insulation boards for pitched roofs*

[BS 5250](#), *Code of practice for control of condensation in buildings*³

[BS 6100-6](#), *Building and civil engineering — Vocabulary — Part 6: Construction parts*

[BS 8000-6](#), *Workmanship on building sites — Code of practice for slating and tiling of roofs and claddings*⁴

[BS 8417](#), *Preservation of wood — Code of practice*

A2 [BS 8612](#), *Dry-fixed ridge, hip, and verge systems for slating and tiling — Specification* **A2**

[BS 9250](#), *Code of practice for design of the airtightness of ceilings in pitched roofs*

² **A2** Historic England – www.historicengland.org.uk (last viewed 30 January 2018). **A2**

³ This standard also gives informative references to BS 5250:2011.

⁴ This standard also gives an informative reference to BS 8000-6:2013.

- BS EN 197-1:2011, *Cement — Part 1: Composition, specifications and conformity criteria for common cements*
- BS EN 300:2006, *Oriented strand boards (OSB) — Definitions, classification and specifications*
- BS EN 312:2010, *Particleboards — Specifications*
- BS EN 335, *Durability of wood and wood-based products — Use classes: definitions, application to solid wood and wood-based products*
- BS EN 350-2:1994, *Durability of wood and wood-based products — Natural durability of solid wood — Part 2: Guide to natural durability and treatability of selected wood species of importance in Europe*
- BS EN 485-1, *Aluminium and aluminium alloys — Sheet, strip and plate — Part 1: Technical conditions for inspection and delivery*
- BS EN 485-2, *Aluminium and aluminium alloys — Sheet, strip and plate — Part 2: Mechanical properties*
- BS EN 485-4, *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 for roof covering and wall cladding — 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, *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 — Product specification and test methods*
- 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 — Efficacy of preventive wood preservatives as determined by biological tests — Part 1: Specification according to use class*
- BS EN 607, *Eaves gutters and fittings made of PVC-U — Definitions, requirements and testing*
- BS EN 612, *Eaves gutters with bead stiffened fronts and rainwater pipes with seamed joints made of metal sheet*
- BS EN 622-2:2004, *Fibreboards — Specifications — Part 2: Requirements for hardboards*
- BS EN 622-3:2004, *Fibreboards — Specifications — Part 3: Requirements for medium boards*
- BS EN 622-4:2009, *Fibreboards — Specifications — Part 4: Requirements for softboards*
- BS EN 634-1:1995, *Cement-bonded particle boards — Specification — Part 1: General requirements*
- BS EN 636:2012, *Plywood — Specifications*
- BS EN 934-3, *Admixtures for concrete, mortar and grout — Part 3: Admixtures for masonry mortar — Definitions, requirements, conformity and marking and labelling*
- BS EN 988, *Zinc and zinc alloys — Specification for rolled flat products for building*

- BS EN 1008, *Mixing water for concrete — Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete*
- BS EN 1172, *Copper and copper alloys — Sheet and strip for building purposes*
- BS EN 1304, *Clay roofing tiles and fittings — Product definitions and specifications*
- BS EN 1462, *Brackets for eaves gutters — Requirements and testing*
- BS EN 1873, *Prefabricated accessories for roofing — Individual rooflights of plastics — Product specification and test methods*
- BS EN 1990, *Eurocode — Basis of structural design*
- BS EN 1991-1-1, *Eurocode 1 — Actions on structures — Part 1: General actions — Section 1: Densities, self-weight, imposed loads for buildings*
- BS EN 1991-1-3, *Eurocode 1 — Actions on structures — Part 1: General actions — Section 3: Snow loads*
- BS EN 1991-1-4, *Eurocode 1 — Actions on structures — Part 1: General actions — Wind actions*
- BS EN 1993-1-1, *Eurocode 3 — Design of steel structures — Part 1: General rules and rules for buildings*
- BS EN 1995-1-1, *Eurocode 5 — Design of timber structures — Part 1: General — Common rules and rules for buildings*
- BS EN 10048, *Hot rolled narrow steel strip — Tolerances on dimensions and shape*
- BS EN 10051, *Continuously hot-rolled strip and plate/sheet cut from wide strip of non-alloy and alloy steels — Tolerances on dimensions and shape*
- BS EN 10088-3:2005, *Stainless steels — Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes*
- 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 10268, *Cold rolled steel flat products with high yield strength for cold forming — Technical delivery conditions*
- BS EN 12056-3, *Gravity drainage systems inside buildings — Part 3: Roof drainage, layout and calculation* ⁵⁾
- BS EN 12200-1, *Plastics rainwater piping systems for above ground external use — Unplasticized poly (vinyl chloride) (PVC-U) — Part 1: Specifications for pipes, fittings and the system*
- BS EN 12326-1, *Slate and stone products for discontinuous roofing and cladding — Part 1: Product specification*
- BS EN 12326-2, *Slate and stone for discontinuous roofing and external cladding — Part 2: Methods of test for slate and carbonate slate*
- BS EN 12588, *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 13304, *Bitumen and bituminous binders — Framework for specification of oxidised bitumen*
- BS EN 13139, *Aggregates for mortar*

⁵⁾ This standard also gives informative references to the complete BS 12056 series.

BS EN 13162, *Thermal insulation products for buildings — Factory made mineral wool (MW) products — Specification*

BS EN 13163, *Thermal insulation products for buildings — Factory made expanded polystyrene (EPS) products — Specification*

BS EN 13164, *Thermal insulation products for buildings — Factory made extruded polystyrene foam (XPS) products — Specification*

BS EN 13165, *Thermal insulation products for buildings — Factory made rigid polyurethane foam (PU) products — Specification*

BS EN 13166, *Thermal insulation products for buildings — Factory made phenolic foam (PF) products — Specification*

BS EN 13168, *Thermal insulation products for buildings — Factory made wood wool (WW) products — Specification*

BS EN 13170, *Thermal insulation products for buildings — Factory made products of expanded cork (ICB) — Specification*

BS EN 13171, *Thermal insulation products for buildings — Factory made wood fibre (WF) products — Specification*

BS EN 13353:2008+A1:2011, *Solid wood panels (SWP) — Requirements*

BS EN 13859-1, *Flexible sheets for waterproofing — Definitions and characteristics of underlays — Part 1: Underlays for discontinuous roofing*

BS EN 14963, *Roof coverings — Continuous rooflights of plastics with or without upstands — Classification, requirements and test methods*

BS EN 14964, *Rigid underlays for discontinuous roofing — Definitions and characteristics*

BS EN 62305 (all parts), *Protection against lightning*

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

[BS ISO 6707-1](#), *Buildings and civil engineering works — Vocabulary — Part 1: General terms*

Other publications

[N1] NATIONAL FEDERATION OF ROOFING CONTRACTORS. *Wooden shingles*. Technical Bulletin 34. London: National Federation of Roofing Contractors, 2014.

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in [BS 6100-6](#), [BS 5250](#), [BS 9250](#), [BS ISO 6707-1](#) and the following apply.

3.1.1 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.

3.1.2 dry fix roofing product or system

roofing product or system that can perform a gap closing function and mechanically fix roofing components without the use of mortar

3.1.3 laps

3.1.3.1 sealed lap

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

3.1.3.2 unsealed lap

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

3.1.4 pitched roofs

3.1.4.1 pitched roof

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

3.1.4.2 rafter pitch

angle of elevation of a roof structure from the horizontal

NOTE The rafter pitch is otherwise used to specify the minimum or maximum pitch of a discontinuously laid overlapping roofing element.

3.1.5 rain

3.1.5.1 deluge rain

high rainfall without wind

3.1.5.2 driving rain

rainfall with wind

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

3.1.6 snow

snowfall with or without wind

3.1.7 structural deck sarking

structural insulated deck spanning between ridge and eaves, that replaces conventional rafters including, where appropriate, intermediate support from purlins

3.1.8 tenting

transfer of moisture through a permeable material, initiated by contact

3.1.9 underlays

3.1.9.1 high water vapour resistance (type HR) underlay

underlay that has a water vapour resistance in excess of 0.25 MN·s/g, which effectively prevents the transfer of water vapour

3.1.9.2 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.

3.1.9.3 low water vapour resistance (type LR) and air permeable underlay

underlay that has a water vapour resistance not more than $0.25 \text{ MN}\cdot\text{s/g}$ combined with an air permeability of not less than $20 \text{ m}^3/\text{m}^2\cdot\text{h}$ at 50 Pa which allows for the transfer of both water vapour and air

NOTE The stated figure for air permeability relates to wind uplift resistance and does not take into consideration condensation control. Further information on tests for air permeability can be found in BS EN 12114.

3.1.10 ceilings

3.1.10.1 continuous ceiling

ceiling with an air permeability of $\leq 0.03\%$, i.e. an average of $\leq 30 \text{ mm}^2$ per square metre

3.1.10.2 discontinuous ceiling

ceiling with an air permeability of $> 0.03\%$, i.e. an average of $> 30 \text{ mm}^2$ per square metre 

3.2 Symbols

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

A	valley gutter width, in metres (m)
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 ($^\circ$)
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)
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)
$\boxed{A_1}$ Text deleted $\boxed{A_1}$	
C_{hk}	characteristic hook failure load, in newtons (N)
c	driving rain head-lap factor for slates, in metres (m)
c_{pe}	external pressure coefficient
c_{pi}	internal pressure coefficient for the underside of an element
$c_{p,net}$	net uplift coefficient
c_s	size factor
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_{max}	maximum displacement of tile D, in millimetres (mm)
d_n	nail diameter, in millimetres (mm)
d_{pc}	critical pressure difference, in newtons per square metre (N/m ²)
d_s	screw shank diameter, in millimetres (mm)
d_u	upward deflection of underlay, in millimetres (mm)
E	modulus of elasticity of a fixing, in newtons per square millimetre (N/mm ²)
E_1	driving rain side-lap factor for slates
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_{TI}	test load, in newtons (N), representing either $F_{T,max}$ or $F_{T,S}$
$F_{T,max}$	maximum test load at failure, in newtons (N)
$F_{T,S}$	test load at the serviceability limit, 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_{hk}	resistance provided by a slate hook, in newtons (N)
F_n	nail uplift load in a clipped and head-nailed 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_s	screw total withdrawal resistance in a ridge tile, in newtons (N)

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_u	wind pressure factor for underlays
f_x	extreme fibre bending stress about the x-x axis, in newtons per square millimetre (N/mm ²)
f_y	extreme fibre bending stress about the y-y axis, in newtons per square millimetre (N/mm ²)
G_a	batten gauge, in metres (m)
G_{hk}	length of the part of a slate hook which grips the slate, in millimetres (mm)
g	acceleration due to gravity (9.81 m/s ²)
H	building height, in metres (m)
h_g	nail holing gauge for double-lap slating, in metres (m)
h_1	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 millimetres to the power 4 (mm ⁴)
I_y	second moment of area of a batten in the y-y axis, in millimetres to the power 4 (mm ⁴)
K	pressure drop coefficient
K_{Fi}	consequence factor on actions relating to reliability class of structure
K_b	depth factor for strength of a batten
K_n	fixing resistance factor (used for the mechanical fixing at every number of courses held down by a fixed 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 number of wind uplift resistance tests conducted
L	building length, in metres (m)
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 on 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 roofing element at the eaves, 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 tile 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 live load on a batten, in metres (m)
[A1] Text deleted [A1]	
M	maximum bending moment in a fixing, in newton millimetres (N·mm)
M_a	total aerodynamic moment, in newton metres (N·m)
M_{Fh}	aerodynamic moment from horizontal wind load, in newton metres (N·m)
M_{Ftr}	aerodynamic moment from vertical wind load, in newton metres (N·m) restoring
M_g	moment due to self-weight, in newton metres (N·m)
M_{hk}	resistance moment of a slate hook, in newton metres (N·m)
M_n	nail [A1] /screw [A1] withdrawal resistance moment, in newton metres (N·m) total
M_r	restoring moment due to a slate's mass and fixings, in newton metres (N·m)
M_s	restoring moment due to a screw, in newton metres (N·m)
M_u	wind uplift moment, in newton metres (N·m)
M_w	resistance 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 newton metres (N·m) bending
M_y	moment of a batten about the y-y axis, in newton metres (N·m)
m	mass of ridge tile, in kilograms (kg)
N_n	nail pull-out resistance, in newtons per millimetre (N/mm)
N_s	screw pull-out resistance, in newtons per millimetre (N/mm)
n	number of tests conducted

n_c	number of courses of roofing elements held down by one fixed course
n_u	number of unsealed roofing elements under test
p_D	$\boxed{A_2}$ underlay wind uplift resistance, taken as the declared mean test pressure, in newtons per square metre (N/m ²) $\boxed{A_2}$
p	distance from the centre of gravity to the axis of rotation, in metres (m)
p_u	wind pressure acting on an underlay, in newtons per square metre (N/m ²)
Q_C	volume flow rate, in cubic metres per second (m ³ /s)
q	distance from the uplift force to the axis of rotation, in metres (m)
q_p	peak velocity pressure of the wind at a particular location, in newtons per square metre (N/m ²)
R	uplift pressure reduction factor
R_F	fixing spacing in a continuous counterbatten, 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_i	individual hook failure load, in newtons (N)
$\boxed{A_1}$	<i>Text deleted</i> $\boxed{A_1}$
R_{kx}	characteristic value of the fastener uplift resistance $\boxed{A_1}$ at the ultimate or serviceability limit state $\boxed{A_1}$, in newtons (N)
$R_{kx,s}$	characteristic value of the fastener uplift resistance at the serviceability limit state, in newtons (N)
$\boxed{A_2} R_{kx, MAX} \boxed{A_2}$	characteristic value of the fastener uplift resistance at the ultimate limit state, in newtons (N)
R_n	nail $\boxed{A_1}$ /screw $\boxed{A_1}$ withdrawal resistance, in newtons (N)
R_s	rafter spacing, in metres (m)
R_x	average test load of a clip from a population of n samples, in newtons (N)
r	distance from a clip to the axis of rotation, in metres (m)
S	roof substrate shielding factor
s_f	standard deviation of fastener uplift resistance, in newtons (N)
$s_{f,max}$	standard deviation of fastener at maximum failure load, in newtons (N)
$s_{f,s}$	standard deviation of fastener load at serviceability limit, in newtons (N) side-lap for double-lap slating, in metres (m)
s_l	lap for double-lap slating, in metres (m)
s_{min}	minimum side-lap for double-lap slating, in metres (m)
s_y	maximum batten deflection in the y direction, in millimetres (mm)
T_{hk}	peak to peak dimension of the crimp of a slate hook, in millimetres (mm) slate
t	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)
W	building width, in metres (m)

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_b	bow distortion of tiling batten, in millimetres (mm)
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_x	component load in the x-x axis from a vertical load, in kilonewtons (kN)
W_y	component load in the y-y axis from a vertical load, in kilonewtons (kN)
w	width (parallel to the battens) of a local roof area, in metres (m)
w_d	mass per unit area of a roofing element, converted into 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 kilonewtons per metre (kN/m)
w_y	component load on a batten in the y-y axis, in kilonewtons per metre (kN/m)
X	width of a roof obstruction, in metres (m)
X_b	spring distortion of tiling batten, in millimetres (mm)
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	length of a roof obstruction, in metres (m)
Y_b	twist distortion of a tiling batten, in millimetres (mm)
y	dimension of the local area surrounding a roof obstruction, in metres (m)
Z	height 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 cubic millimetres (mm ³)
Z_y	section modulus of a timber batten in the y-y axis, 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 (°)
γ_F	load safety factor
γ_G	permanent load (e.g. self-weight) safety factor
γ_M	material safety factor
γ_Q	variable load safety factor for snow and wind loads
δ	deflection of a fixing through insulation, in millimetres (mm)
θ	pitch of a laid slate, tile or shingle from the horizontal, in degrees (°)
$\emptyset$	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 Reclaimed or recycled materials might not conform to the relevant standards.

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

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

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

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

4.3 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 [2], which require health and safety precautions to be taken. Further guidance on the repair, maintenance and removal of roofing materials containing asbestos-containing materials (ACMs) is given in HSG 33 [3]. 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.

4.4 Natural slates and fittings

Natural slates should conform to BS EN 12326-1.

NOTE Guidance on selection of natural slates is given in NFRC Technical Bulletin 04a [4].

4.5 Bitumen shingles

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

4.6 Proprietary products

This British Standard makes frequent reference to the use of proprietary products, i.e. products not manufactured to another British Standard.

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.

4.7 Wooden shingles and shakes

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

Wooden shingles and shakes should be preservative treated to extend their durability and service life.

NOTE 2 Further guidance on the specification and use of wooden shingles and shakes is given in NFRC Technical Bulletin 34 [N1].

4.8 Metal tiles

NOTE There is no British Standard for metal tiles.

Metal tiles should be manufactured from corrosion-resistant metals or metals treated to provide durability, with adequate strength to resist the dead and imposed loads as determined by BS EN 1991-1-1, BS EN 1991-1-3 and BS EN 1993-1-1.

4.9 Roofing underlay

4.9.1 General

The roofing underlay should be of suitable strength, water resistance and durability for the proposed application.

NOTE 1 Data to be used for the assessment of suitable materials can be obtained by testing in accordance with BS EN 13859-1.

An underlay used beneath a roof or wall covering of tiles, slates or wooden shingles should:

- a) provide a barrier that reduces the wind uplift load acting on the slates or tiles (as determined in accordance with [Annex A](#));
- b) provide a secondary barrier to the ingress of wind-driven rain, 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 that might be deposited onto the surface of the underlay in the batten space;
- d) in the case of a vapour permeable underlay, be in accordance with the recommendations for a type LR underlay as given in [BS 5250](#);
- e)  provide temporary weather protection before the installation of the primary roof covering. An exposed underlay is subjected to UV light which might lead to premature failure; therefore, the exposure period should be kept to a minimum. In certain conditions, particularly if there is persistent heavy rainfall combined with subsequent severe freeze/thaw conditions, an underlay should not be exposed for more than a few days.

NOTE 2 If an underlay has to be left without a roof covering for a period of time when adverse rainfall and weather is expected, a tarpaulin or similar protective sheeting may be used to protect the underlay until such time that the roof covering can be completed. 

Underlays should be capable of withstanding the following conditions.

- 1) **Tenting.** Materials that are susceptible to tenting should not be used.

NOTE 3 Advice on the susceptibility of the underlay to tenting may be obtained from the manufacturer.

- 2) **Fixing penetrations.** Nail holes through underlays should not be subject to enlargement due to shrinkage or nail tear as a result of wind uplift loading.

 Text deleted 

NOTE 4 BS EN 13859-1 describes a test for tear resistance of roofing underlays. Proprietary products exist for sealing fixing penetrations in non-bituminous underlays.

NOTE 5 The use of staples for fixing underlays does not provide the same level of protection against water penetration as clout head nails.

- 3) **Wind uplift.** The tensile strength of the underlay, when laid unsupported, should be capable of resisting the calculated wind uplift loads within the acceptable levels of extensibility, without causing interference to the underside of the roof covering when laid at the required batten

gauge. The uplift resistance of unsupported roof underlays should be determined in accordance with [Annex A](#).

- 4) **Moisture penetration.** Underlays should be capable of resisting the penetration of moisture where their upper surface might be subject to melting snow, rainwater or condensation droplets.

NOTE 6 BS EN 13859-1 describes a test for water penetration of roofing underlays. Products which meet the classification requirements of Class W.1 are deemed to be suitable for use in UK conditions.

4.9.2 Fully supported underlays

NOTE Underlays may be laid fully supported over suitable rigid boards or sheets as described in [4.10](#).

4.9.2.1 Sheet sarking

For fully supported underlays, both type LR and type HR, ventilation should always be provided beneath the sheet sarking (see [Annex B](#), [B.1](#) and [BS 5250](#)).

A1 Text deleted A1

4.9.2.2 Square-edged board sarking

For underlays supported on square-edged timber sarking boards, ventilation should always be provided beneath the sarking when an HR underlay is used. When a type LR underlay is used, the ventilation should be in accordance with [BS 5250](#).

NOTE Underlays used as a temporary covering over continuous sarking boards (as in Scottish practice) may remain in place after the fixing of natural slates which are directly nailed through the underlay to the boarding.

4.9.3 Unsupported flexible underlays

NOTE 1 Underlays may be laid draped over rafters or counterbattens suited to their tensile strength.

The roofing underlay should be of suitable strength, water resistance and durability for the proposed application. One of the following types of unsupported underlay should be used:

- a) reinforced bituminous flexible underlay meeting the recommendations for type 1F or type 5U given in [Annex C](#);
- b) non-bituminous flexible underlay meeting the recommendations given in [4.9.1](#) when tested in accordance with BS EN 13859-1 (see Note 2 and Note 3).

NOTE 2 When selecting the roofing underlay, designers and specifiers are advised to determine the classification of the underlay both in terms of its vapour resistance (HR or LR) and resistance to wind uplift (see [BS 5250](#) and [Annex A](#)).

NOTE 3 Attention is drawn to the need for adequate water resistance, tensile and nail-tear resistance, water vapour permeability and durability (see [4.9.1](#)). BS EN 13859-1 provides test methods to assess such performance characteristics.

NOTE 4 Further guidance is given in NFRC Technical Bulletin 06 [\[6\]](#).

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

NOTE 5 Products that meet the requirements of BS EN 13859-1 cold bend temperature of -10°C are deemed to have sufficient flexibility for use in the UK.

4.9.4 Rigid underlays

Rigid underlays should usually conform to BS EN 14964 (see Note) and may comprise flat or profiled sheets, wood based panels, fibre-cement sheets, corrugated bitumen sheets or sheets of other materials.

NOTE Rigid underlays not conforming to BS EN 14964 may be used provided that the specifier has obtained evidence that these products are fit for purpose either by proven relevant experience or test method data based on the conditions and methods of use in the UK climate.

4.10 Board and sheet sarking

4.10.1 General

Board and sheet sarking should conform to the standards listed in [4.10.2](#). Other types of board and sheet sarking, including their minimum thicknesses, should conform to BS EN 14964.

4.10.2 Materials for board and sheet sarking

Board and sheet sarking used in pitched roof construction should conform to the standards listed in [Table 1](#).

4.10.3 Insulated board sarking

Insulated board sarking used in pitched roof construction should conform to the standards listed in [Table 2](#). Where insulation is placed at rafter level, pitched roof systems should be designed and installed in accordance with [Annex B](#).

The insulation specification adopted should be designed to control the rate of heat loss by conduction, convection and radiation.

Table 1 — *Material specifications for board and sheet sarking*

Material	Standard and type
Timber boarding (square edged or tongued and grooved)	BS EN 13353:2008+A1:2011, type SWP/2
Medium board	BS EN 622-3:2004, types 3, 4
Hardboard	BS EN 622-2:2004, types 3, 4
Particleboard	BS EN 312:2010, type P3
Cement bonded particleboard	BS EN 634-1
Oriented strand board (OSB)	BS EN 300:2006, type 3
Plywood	BS EN 636:2012, type 2
Wood wool	BS EN 13168

Table 2 — *Material specifications for insulated board sarking*

Insulation	Standard and type
Mineral wool (MW)	BS EN 13162
Expanded polystyrene (EPS)	BS EN 13163
Extruded polystyrene (XPS)	BS EN 13164
Polyurethane/polyisocyanurate foam (PUR/PIR)	BS 4841-5 or BS EN 13165
Phenolic foam (PF)	BS EN 13166
Wood fibre board (WF)	BS EN 13171
Expanded cork (ICB)	BS EN 13170
Fibre building board (softboard)	BS EN 622-4:2009, type SB.H

In addition, the insulation layer, in combination with an effective air and vapour control layer (AVCL) or well-sealed ceiling when required, should adequately limit the risk of surface or interstitial condensation.

NOTE [BS 5250:2011](#), Annex D and Annex H contain further guidance on the assessment of particular roofs, and design principles for prevention of condensation problems within constructions of this type.

4.10.4 Structural deck sarking

NOTE There is no British Standard for structural deck sarking.

Structural deck sarking should comprise one of the following:

- a) profiled metal trough shaped panels (also known as liner trays), the troughs of which are filled with insulation; or
- b) metal faced sandwich panels with foamed plastics insulation bonded to the metal faces; or
- c) wood-based board faced sandwich panels with foamed plastics insulation bonded to the faces [also known as structurally insulated panels (SIPs)], which are laid side by side and connected to each other to form a continuous deck; or
- d) reinforced pre-cast concrete panels with foamed plastics insulation bonded to the faces, which are interlocked together to form a continuous deck.

4.11 Timber battens and counterbattens

4.11.1 Timber species

Timber battens and counterbattens should be of the following species ⁶:

- a) British-grown ⁷:
 - larch [WLAD];
 - British pine [WPNN];
 - British spruce [WPCS];
- b) imported:
 - redwood [PNSY];
 - whitewood [WPCA];
 - spruce-pine-fir (USA, Canada) [WPCE];
 - southern pine (USA) [WPNE].

4.11.2 Permissible characteristics and defects

Characteristics and defects in timber battens should not exceed the limits given in [Annex D](#).

Timber battens should be graded according to the criteria given in [Annex D](#) and marked in accordance with [4.11.5.2](#).

A1 Timber counterbattens subject to upward bending load should be graded in accordance with [Annex D](#) and [4.11.5.2](#).

NOTE For example when used to hold down insulation board against wind uplift and are secured to the rafters by fixings.

Timber counterbattens should be free from rot and live insect attack. **A1**

⁶ The four-letter codes in parentheses denote the abbreviated species identification codes given in BS EN 13556.

⁷ For the purposes of this British Standard, "British-grown" species are those grown in the United Kingdom and the Irish Republic.

4.11.3 Preservative treatment

If preservative treatment is necessary, it should be carried out in accordance with [Annex E](#).

NOTE 1 Expected in-service conditions indicate whether or not to treat tiling or slating battens with a preservative. Attention is drawn to the Building Regulations 2010 [7] 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.

4.11.4 Sizes

4.11.4.1 Minimum sizes

Timber batten sizes should be not less than the minimum values recommended in [Table 3](#) for the common applications listed.

4.11.4.2 Other sizes

Battens for spans greater than those given in [Table 3](#), or for other loading conditions, should be designed by structural calculation for strength and stiffness in accordance with [Annex F](#), but their sizes should be not less than those given in [Table 3](#) 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 should be within the tolerances given in [Table 3](#).

NOTE 1 Examples of battens designed by calculation are given in [Annex G](#).

NOTE 2 Battens are expected to resist the loadings on the completed slate or tile roof but do not necessarily provide a safe place of work for the slater/tiler during the installation of the roof covering.

NOTE 3 Attention is drawn to HSG 33 [3], which requires the roofing operative to have a safe place of work and a platform with safe access to work, including the adequacy of battens as secure footholds for the span at which they are to be used.

NOTE 4 Additional guidance is provided in NFRC Guidance Sheet Q [8].

Table 3 — Minimum timber batten sizes (roofing and vertical work)

Application	Basic minimum size of batten ^{A), B), C)}			
	Up to 450 mm span ^{D)}		451 mm 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

Table 3 (continued)

Application	Basic minimum size of batten ^{A), B), C)}			
	Up to 450 mm span ^{D)}		451 mm to 600 mm span ^{D)}	
	Width mm	Depth mm	Width mm	Depth mm
^{A)} Tolerances on the basic sizes of timber batten should be: width ± 3 mm, depth $\frac{-0}{+3}$ mm, based on measurement at a reference moisture content of 20% (see Annex D). ^{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 faces 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.				

4.11.4.3 Minimum batten length

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

4.11.4.4 Counterbattens

The dimensions of counterbattens should be sufficient to provide a ventilation gap as recommended in [BS 5250](#) and/or to provide a drainage path beneath the battens.

4.11.5 Identification

4.11.5.1 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 [4.11.1](#));
- c) graded in accordance with BS 5534 ⁸;
- d) basic size or sizes;
- e) type of preservative and method of treatment, if applicable.

NOTE Further guidance on preservative treatments for timber tiling battens is given in [Annex E](#).

4.11.5.2 Marking

Each batten should be indelibly marked with the following information:

- a) supplier;
- b) origin (imported or British-grown, and/or species code – see [4.11.1](#));
- c) “graded BS 5534” ⁹;

⁸ Marking BS 5534 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.

⁹ Marking BS 5534 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.

d) size.

NOTE Further guidance on the specification and use of timber tiling battens and counterbattens is given in NFRC Technical Bulletin 33 [9].

4.12 Mechanical fixings

4.12.1 Nails

4.12.1.1 General

For nails intended to be used as fixings:

- zinc-coated steel nails should be coated using any one of the zinc or zinc alloy coating methods specified in BS EN 10230-1;
- stainless steel nails should conform to BS EN 10088-3:2005, grade 304 or 316;
- copper nails should conform to [BS 1202-2](#);
- aluminium nails should conform to [BS 1202-3](#);
- nails made of other materials, including phosphor or silicon-bronze, should be of the required type, dimensions, strength and durability to satisfy the conditions of use in accordance with the manufacturer's specification.

When selecting the type of nail for each application, account should be taken of the effects on its mechanical and chemical properties when in contact with dissimilar metals or exposure to chemical salts that might be present in its final location.

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

4.12.1.2 Nails for battens, counterbattens, boarding and roofing underlays

Nails for use with battens, counterbattens and boarding (board sarking) should be zinc-coated in accordance with BS EN 10230-1.

For battens and counterbattens, nails should generally be round plain shank of not less than 3.35 mm shank diameter. Indented, spiral roll and annular ring shank nails may also be used. The length and type of nail to be used should be determined according to the exposure of the site. Cut nails or proprietary fixings should be used only for masonry wall applications (see also [5.3.6.8](#), [Annex B](#) and [Annex H](#)).

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.

Nails for use with roofing underlays should be clout head-nails of not less than 3.0 mm shank diameter, made of material meeting the recommendations given in [4.12.1.1](#).

NOTE Where proprietary nail fixings are to be applied using mechanical nail guns, designers and specifiers are advised to seek guidance from the manufacturer as to their suitability for the intended use.

4.12.1.3 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 also [Annex H](#)).

4.12.1.4 Nails for slates, tiles and shingles

Nails for slates and tiles should be made of the following materials:

- slates: copper, aluminium, phosphor or silicon-bronze;

- tiles: copper, aluminium, stainless steel, phosphor or silicon-bronze.

NOTE Guidance on the type of nails used for wooded shingles or shakes is given in NFRC Technical Bulletin 34 [N1].

4.12.2 Clips for tiles

Where clips are used for securing tiles, evidence should be obtained from the manufacturer of their suitability in terms of durability and strength (see [Annex I](#)); 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 or BS EN 10088-3:2005, grade 302, 304 or 316.

Clips made of other materials such as different 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 I](#)) and durability for the intended conditions of use.

4.12.3 Hooks and rivets for slates

4.12.3.1 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. The uplift resistance of nail hook fixings should be determined in accordance with [Annex J](#) (see [Annex K](#) 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. Evidence should be obtained from the slate manufacturers 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, secured by the edges of the two slates in the course below, through the gap between them.

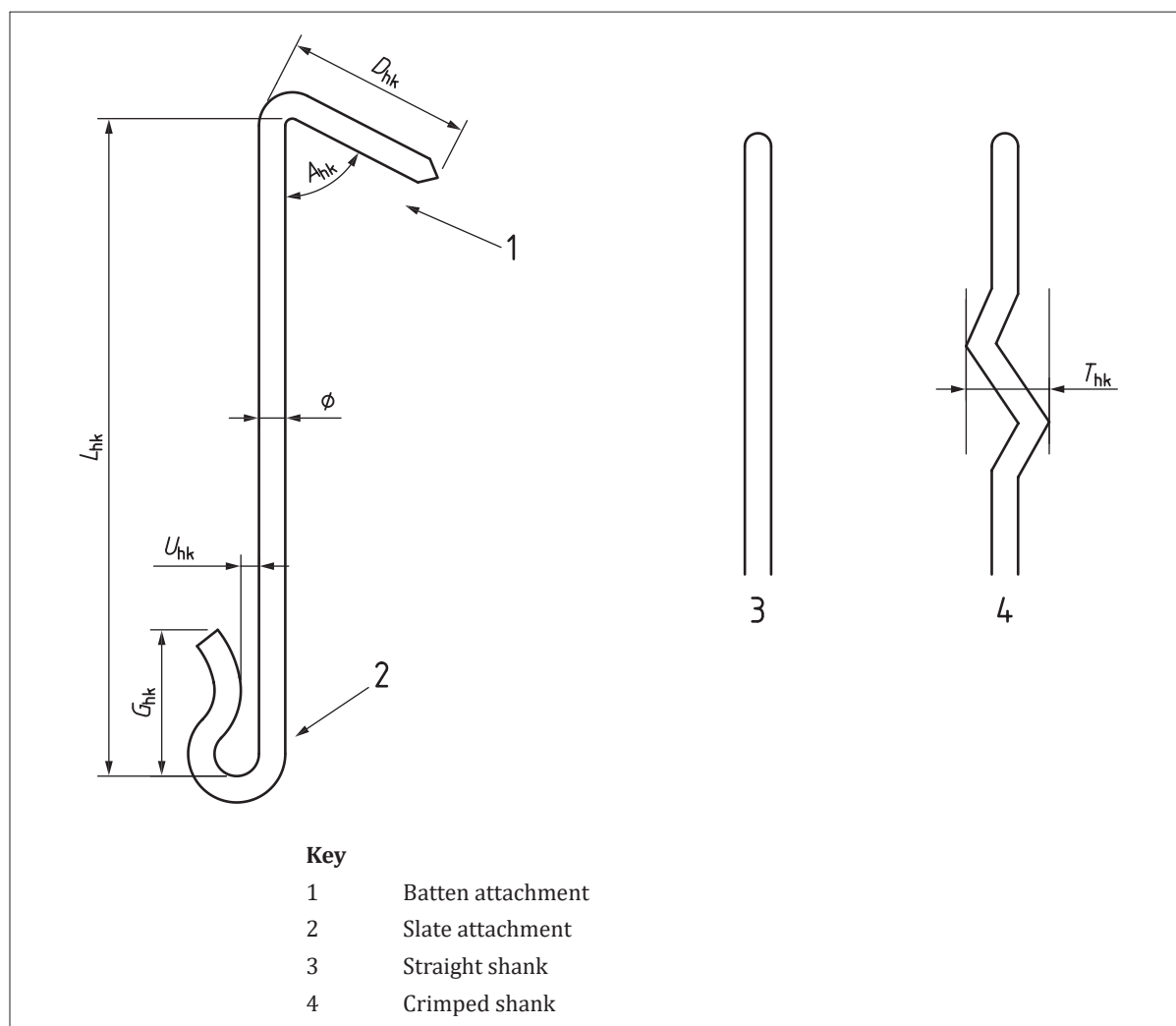
4.12.3.2 Hooks

Hooks intended for slating should be $\boxed{A_2}$ drive-in $\langle A_2 \rangle$ slate hooks formed from stainless steel wire conforming to BS EN 10088-3:2005, grade 316, and should have the dimensions recommended in [Table 4](#) and [Figure 1](#).

Table 4 — Dimensions of $\boxed{A_2}$ drive-in $\langle A_2 \rangle$ 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 J)
Slate grip gap U_{hk}	See 4.12.3.2
Slate grip length G_{hk}	(16.0 ±2.0) mm
Spike length D_{hk}	Slate thickness +20 mm, or to resist the calculated wind uplift forces (see 5.3.6.13 and K.2.5.1) using the strength value determined by the test method given in Annex J , whichever is the larger
Spike angle A_{hk}	(70 ±5)°
Crimp dimension T_{hk}	<5 mm

^{A)} See [Figure 1](#).

Figure 1 — **A2** Drive-in **A2** slate hook dimensions

Typically, slate hooks are fitted between the perpendicular joints of each slate with the spike at the upper end driven into the batten and the curved hook at the opposite end located over the leading edge of the overlapping slate. The shank may be straight or crimped (see [Figure 1](#)); if it is crimped, the crimps should be in the same plane as the roof slope.

NOTE 1 Hooks with crimped shanks reduce the capillary rise of water at the perpendicular joints between slates (see [5.3.6.13](#) and [5.4.2.6.3](#)).

NOTE 2 Slate hooks designed to wrap around the batten are not recommended for UK conditions of use.

The peak to peak 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 $\emptyset$) 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 [Annex H](#) and [Annex J](#)) using the strength value determined by the test method given in [Annex J](#).

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.

4.13 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 5](#).

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.

4.14 Mortar

The properties of a mortar, in both the fresh wet state and the finished hardened state, can be affected by the type of sand used and also by the cleanliness of the water. The sand should therefore be well graded and conform to BS EN 13139, and the water should be obtained from a potable supply.

Materials for use in mortar should conform to the following standards:

- a) cement: BS EN 197-1:2011 (Portland cement to class 42.5);
- b) sand: BS EN 13139;
- c) hydrated lime: manufacturer's recommendations;
- d) hydraulic lime: manufacturer's recommendations;
- e) water: BS EN 1008;
- f) admixtures: BS EN 934-3;
- g) pigments: BS EN 12878. The addition of pigments or colour additives to the mortar mix should not exceed a ratio of one part pigment to sixty parts of mortar;
- h) plasticizers: manufacturer's recommendations.

Mortar should typically consist of the mixes given in [Table 6](#).

Table 5 — *Materials for 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)	1.80 (code 4)	1.80 (code 4)	1.80 (code 4)	1.32 (code 3)
Copper ^{B)}						
• fully supported	BS EN 1172	0.45 to 0.70 ^{C)} (type 1/8 H)	0.45 to 0.70 ^{C)} (type 1/8 H)	0.55 (type "fully annealed")	0.55 (type "fully annealed")	0.55 (type "fully annealed")
• self-supported	BS EN 1172	—	0.70 (type 1/2 H)	—	—	—
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

Table 5 (continued)

Material	Material Standard	Minimum thickness				
		Horizontal gutters mm	Inclined valleys mm	Flashings mm	Saddles mm	Soakers mm
A) Further advice is available from the Lead Sheet Association.						
B) Further advice is available from the Copper Development Association. Guidance for fully supported roofing products is given in BS EN 504.						
C) Depending upon valley width.						
D) Further advice is available from the Council for Aluminium in Buildings. Guidance for fully supported roofing products is given in BS EN 507.						
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. Guidance for fully supported roofing products is given in BS EN 501.						

Table 6 — Recommended standard mortar mixes for slating and tiling (all proportions by volume)

Type	Mix
3:1 with blended sand	Soft sand and sharp sand mix, with the sharp sand making up no less than one third of the sand content, to one part Portland cement and plasticizer in accordance with manufacturers' instructions.
3:1 with coarse building sand	Some building sands are coarse in nature and have been found to have a size particle distribution in line with a blended mix of fine building sand and sharp sand. Where 70% to 90% of the sand is able to pass through an 0.5 mm sieve, this may be used as part of a 3:1 sand cement mix with plasticizer, in accordance with manufacturers' instructions.
Proprietary roofing mortar	Proprietary mortars should be mixed and applied in accordance with manufacturers' instructions.

NOTE 1 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 2 Guidance on the use of mortar is given in NFRC Technical Bulletin 27 [10].

NOTE 1 Sand for use in mortar for slating and tiling has traditionally been defined as being either sharp sand or soft sand. BS EN 13139:2002, Annex B defines sand as coarse, medium or fine and provides tables to determine each type.

NOTE 2 Hydrated and hydraulic lime is available to improve the working properties of mortar and is produced to meet the requirements for mortar when mixed with sand, for conservation, restoration and new build construction in roofslating and tiling. Guidance on the use of mortar for historic roofs will be given in NFRC Technical Bulletin 42 [11] (in preparation).

NOTE 3 Mortar admixtures may be used to improve the specific properties of the mortar and are subject to manufacturers' dosage recommendations.

NOTE 4 Air entrainers (plasticizers) improve the frost resistance and workability of the mortar.

4.15 Other fittings and accessories

4.15.1 Eaves filler units

NOTE 1 There is no British Standard for eaves filler units.

Where eaves filler units are used, they should be appropriate for the roof covering and should be fitted in accordance with the manufacturer's instructions.

NOTE 2 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.

4.15.2 Undercloak

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

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

4.15.3 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.

4.15.4 Hip irons

Hip irons should be formed from steel strip conforming to BS EN 10268, and should be hot dip galvanized in accordance with BS EN ISO 1461 after cutting, forming and holing. The steel strip should meet the following recommendations.

- For all roof pitches, hip irons should usually be 25 mm wide and have a thickness of not less than $\sqrt{A_1}$ 4 mm $\sqrt{A_1}$ (see Note).

NOTE Smaller hip irons may be used for small hips, e.g. on bay windows.

- Upstands should be of an adequate length to support the hip tile.
- The flat section along the hip rafter should be not less than $\sqrt{A_1}$ 270 mm $\sqrt{A_1}$ in length and should have two holes to enable it to be fastened with at least two $\sqrt{A_1}$ 3.5 mm $\sqrt{A_1}$ diameter screws or $\sqrt{A_1}$ 3.35 mm diameter $\sqrt{A_1}$ nails, coated using any one of the zinc or zinc alloy coating methods specified in BS EN 10230-1.
- $\sqrt{A_1}$ The holes should be not less than 115 mm apart and not more than 65 mm from the tail of the hip iron.

The point side penetration of screws or nails for fixing the hip iron should be not less than 30 mm. $\sqrt{A_1}$

4.15.5 Valley troughs (preformed)

NOTE 1 There is no British Standard for preformed valley troughs.

Proprietary valley troughs that include preformed GRP, PVC-U and metal products, etc., should have sufficient strength, water impermeability and geometric dimensions to ensure the durability and performance of the roof system.

NOTE 2 Guidance on preformed GRP valley troughs is given in NFRC Technical Bulletin 28 [12].

4.15.6 Translucent slates and tiles

NOTE 1 There is no British Standard for translucent slates and tiles.

Where translucent slates and tiles are used, they should be appropriate for the roof covering and should be fitted in accordance with the manufacturer's instructions.

NOTE 2 Translucent slates, tiles and shingles may be glass or polymer-based (with or without reinforcement).

NOTE 3 Attention is drawn to the Building Regulations 2010, Approved Document B [13], the Scottish Building Standards Technical Handbook, Section 2 [14] and the Building Regulations (NI) 2000 Technical Booklet E [15] with regard to fire precautions.

NOTE 4 If the Construction (Design and Management) Regulations 2007 [16] or the Building Regulations 2010, Approved Document B [13] require some materials to be wire-reinforced, this can limit the number and size of the products that may be used in a roof.

4.15.7 Ventilation products

NOTE 1 There is no British Standard for ventilation products.

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 as recommended in [BS 5250](#) for 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 [5.5.4](#) and not adversely affect the head-laps and side-laps of the slating or tiling.

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

NOTE 2 Guidance on roof ventilation products is given in NFRC Technical Bulletin 20 [17].

4.15.8 Dry fix roofing products

A2 Users should pay particular attention to the resistance to wind loads, rain resistance and durability performance of dry fix roofing products. Dry fixed ridge, hip and verge products should conform to [BS 8612](#).

*NOTE Proprietary dry fix products outside the scope of [BS 8612](#) may be used in accordance with [4.6](#). **A2***

4.15.9 Rainwater products

Rainwater products should conform to the following standards:

- a) PVC-U: BS EN 12200-1, BS EN 1462 and BS EN 607;
- b) metal eaves gutters (unlipped) and downpipes: BS EN 612;
- c) cast iron gutters and downpipes: [BS 416-1](#).

Rainwater products should be fitted to the roof at eaves and at 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 (see [6.13](#)).

4.15.10 Lightning conductors

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

Lightning conductors should conform to the BS EN 62305 series and should be mechanically fixed to resist wind loads.

Lightning conductors and their fixings should not adversely affect the rain resistance of the roof covering.

Lightning conductors and their fixings should be readily accessible for inspection and maintenance.

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

4.15.11 Rooflights

Continuous rooflights manufactured in plastic with or without upstands should conform to BS EN 14963. Individual rooflights manufactured in plastic should conform to BS EN 1873.

The use of rooflights should not adversely affect the performance of the roof.

NOTE 1 A range of proprietary translucent slates and tile products or translucent roof/attic windows may be used in the roof system.

NOTE 2 Rooflights can be manufactured in glass, GRP, PVC or other suitable polymers with or without wire reinforcement.

NOTE 3 Attention is drawn to the need for durability, strength, light transmission and fire performance of rooflights (see [BS 8213-1](#), [BS 8206-2](#), [BS 476-3](#), PD 476-3 and BS EN 12833).

4.15.12 Solar panels

Solar panels should be located such that they do not compromise the integrity of the roof covering. They should be mechanically fixed to resist the wind and snow loads for the building and its location, in accordance with the manufacturer's sitework instructions.

NOTE 1 Guidance on solar panels is given in the Annex to NHBC publication NF30 [\[18\]](#) (which gives a simplified method for determining wind loads on roof-mounted photovoltaic and solar thermal panels), NFRC Technical Bulletin 41 [\[19\]](#) and NFRC Technical Document 01 [\[20\]](#).

NOTE 2 A CEN Technical Report on the structural design of connections between solar panels and the building structure is in preparation.

NOTE 3 When considering the installation of solar panels on listed buildings or buildings in conservation areas, attention is drawn to the need to check with the local planning authority what rules exist concerning their installation.

4.15.13 Snow guards and boards

Where snow guards are used, they should be appropriate for the roof covering and should be fitted in accordance with the manufacturer's instructions.

NOTE 1 Proprietary devices may be used that 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 where the safety of people or the protection of fragile elements below is required, e.g. a glass conservatory.

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

4.15.14 Safety hooks

Safety hooks should conform to BS EN 517.

NOTE 1 Safety hooks are fixed directly to the roof or building structure. Safety ropes or harnesses are attached to them by roofing or maintenance contractors.

Where safety hooks are used, they should be appropriate for the roof covering and should be fitted in accordance with the manufacturer's instructions.

NOTE 2 Attention is drawn to the Construction (Design and Management) Regulations 2007 [\[16\]](#) and BS EN 517.

4.15.15 Roof walkways

NOTE 1 Roof walkways are sometimes required to provide safe access for roof maintenance or to avoid damage to slates or tiles.

Permanently fixed walkways should conform to BS EN 516.

Where roof walkways are used, they should be appropriate for the roof covering and should be fitted in accordance with the manufacturer's instructions.

NOTE 2 Attention is drawn to the Health and Safety at Work, etc. Act 1974 [21].

5 Design criteria

5.1 General

NOTE 1 The design of a pitched roof or vertical wall cladding with a covering of slates or tiles is dictated initially by the shape of the building, the span between the structural elements and the use to be made of the space enclosed by the roof or walls.

Designers, specifiers and users of slates and tiles should take into account the following criteria when selecting products:

- structural stability – dead and imposed loads, wind loads and mechanical resistance;
- weathertightness – rain and snow resistance;
- aesthetics – shape, size and colour;
- durability – product life and corrosion resistance;
- hygrothermal factors – control of condensation and thermal performance;
- health and safety – fire, sound and impact resistance;
- sustainability – environmental performance, recycling and lifecycle.

NOTE 2 Further guidance may be obtained by checking planning and regulatory rules and guidance documents published by the Department for Communities and Local Government (DCLG) (England); the Scottish Executive of the Scottish Government (Scotland); the Office of Estates and Building Standards Division (OBD) of the Northern Ireland Assembly (Northern Ireland); and the Welsh Government (Wales). Other criteria might also be applicable under legislative requirements governing health and safety, the environment and the conservation of energy.

5.2 Structural stability

5.2.1 Basis of design

The basis of structural design should be in accordance with BS EN 1990.

Characteristic loads determined in accordance with BS EN 1991-1-1 (dead and imposed loads), BS EN 1991-1-3 (snow loads) and BS EN 1991-1-4 (wind loads) should be multiplied by load safety factor γ_F and a consequence factor K_{FI} to obtain the design load.

Characteristic strengths or resistances determined in accordance with the appropriate material standard (e.g. BS EN 1993-1-1 for steel and BS EN 1995-1-1 for timber), or derived from tests, should be divided by material safety factor γ_M to obtain the design resistance.

The design resistance should be not less than the design load.

The design to be adopted should be the more unfavourable of the following two situations (see BS EN 1990):

- a) the ultimate limit state (failure) where γ_F (which consists of γ_G and/or γ_Q), K_{FI} and γ_M have the following values:

$\gamma_G = 1.35$ for dead loads acting in the same direction as snow and/or wind loads;

$\gamma_G = 1.0$ for dead loads when acting in the opposite direction to snow and/or wind loads in conjunction with mechanical fasteners, and 0.9 when acting without mechanical fasteners;

$\gamma_Q = 1.50$ for snow and wind loads;

$K_{FI} = 0.9$ (for γ_Q at the ultimate limit state only);

γ_M varies with material, e.g. 1.1 for steel and 1.3 for timber;

or

- b) the serviceability limit state, i.e. the load corresponding to the limit of serviceability (e.g. maximum allowable deformation of tiles under wind uplift) where γ_Q , γ_G , γ_M and K_{FI} are all equal to 1.0.

5.2.2 Dead loads and imposed loads

Account should be taken of dead loads acting on the roof structure (rafters or trusses) from the weight of the roof covering of slates or tiles, battens, underlay and boarding, and any imposed loads such as snow, equipment for maintenance and wind uplift loads.

Dead loads and imposed loads on the roof structure and covering should be calculated in accordance with BS EN 1991-1-1.

NOTE 1 Attention is drawn to the Building Regulations 2010 [7] and regional equivalents [22], [23].

NOTE 2 See also BS 8000-6 concerning the re-roofing of existing structures.

5.2.3 Snow loads

Snow loads should be determined in accordance with BS EN 1991-1-3.

5.2.4 Wind loads

NOTE 1 Wind loads on a pitched roof and vertical cladding are dependent not only on climate and orography but also on the wind direction, wall design, roof shape and pitch.

Wind loads on discontinuously laid small element roofing products and their mechanical resistance should be determined by calculation based on the requirements of BS EN 1990 and BS EN 1991-1-4 and the methodology contained in Annex H, taking the design peak velocity pressure q_p from BS EN 1991-1-4.

NOTE 2 Worked examples of wind uplift and fixing calculations are given in Annex K.

5.2.5 Strength

5.2.5.1 Slates tiles and accessories

Slates, tiles and their fittings should have adequate strength and stiffness to support their own mass and the dead, snow and wind loads. Slates and tiles conforming to requirements for strength given in the relevant product standards and laid in accordance with this British Standard are deemed to be satisfactory.

NOTE Where the relevant British Standard does not include a strength requirement for slates or tiles, or for products that do not have UKAS-accredited third-party certification, it is necessary to obtain evidence that the slates or tiles are fit for purpose.

5.2.5.2 Battens

Battens should be fully graded according to the criteria given in Annex D and marked in accordance with 4.11.5.2, and have adequate strength and stiffness to support the dead, snow and wind loads without impairing the fit of roofing elements (see Annex F and Annex G). They should have sufficient width and depth to accept nailing and should provide adequate withdrawal resistance without splitting and causing excessive bounce when fixing slates or tiles.

Minimum sizes of common timber battens, timber species and grading should be in accordance with 4.11.1, Table 3 and Annex D. Batten sizes for spans greater than those given in Table 3 or for other

loading conditions should be determined by structural design calculation (see [Annex F](#) and [Annex G](#)), but should be not less than the minimum recommended sizes for the relevant application.

Battens should generally be continuous over not less than three supports. Battens should not, under any circumstances, be cantilevered or spliced between supports. Butt joints over intermediate supports should be staggered (see [BS 8000-6](#)).

5.3 Resistance to wind uplift

5.3.1 Mass resistance of roofing products

The mass resistance against uplift and overturning should be taken as 0.9 times the average mass of the roofing element when there are no fixings present.

When fixings act in conjunction with the roofing element, the mass resistance against uplift and overturning should be taken as 1.0 times the average mass of the roofing element.

5.3.2 Resistance of roofing underlay and board sarking

Underlays and board sarking should have adequate resistance and stiffness against the wind loads calculated in accordance with [Annex H, H.6](#). The upward deflection of a flexible underlay under maximum wind uplift load with battens at the maximum design gauge should be such as to avoid contact with the underside of the slates or tiles A2 *Text deleted* A2.

A2 The resistance of the underlay should be calculated for the actual site specific wind loading conditions or may also be classified in accordance with the wind zones given in [Annex A](#).

NOTE [A.7](#) describes the determination of the suitability by test of the design uplift resistance (without excessive ballooning) of the roof underlay against design wind pressure for a particular site. [A.8](#) gives guidance on the classification of underlays for a range of geographical locations and wind zones. A2

5.3.3 Resistance of mechanical fixings

The resistance to wind uplift of mechanical fixings such as clips and slate hooks connected to the roofing substrate should be determined by the method of test given in [Annex I](#) for clips and [Annex I](#) for slate hooks. The withdrawal resistance to wind uplift of nails should be obtained from [Annex H, Table H.5](#), and of screws from [Annex H, Table H.6](#). The uplift resistance of twice nailed plain tiles should be obtained from [Annex H, Table H.8](#).

5.3.4 Resistance of mortar

Any tensile bond strength offered by the mortar bedding of concrete or clay ridge and ridged hip tiles, verge and valley tiles should not be taken into account when determining the mechanical resistance required to resist wind uplift. All mortar-bedded components should be supplemented by mechanical fixings to secure them to the roof structure where the wind uplift load exceeds the dead load resistance.

5.3.5 Combined resistance

In calculating the combined resistance to uplift, the resistance due to the mass of the roofing element, e.g. ridge/hip/verge/valley, may be added to the resistance of the mechanical fixings used to secure such elements, but no account should be taken of the tensile strength of the mortar.

5.3.6 Minimum recommendations for mechanical fixings

5.3.6.1 General

When determining the fixings for roofing elements, the following recommendations should be met.

- a) For both general and local areas, the total uplift resistance of the roof covering element's mass and the mechanical fixings should meet the recommendations given in [5.2](#), [5.3](#) and [Annex H](#).
- b) The perimeter roof cladding elements (see Note 1) should be mechanically fixed using a minimum of two fixings (subject to meeting the wind loading recommendations), one of which can be a tile clip, adhesive or dry verge capping system where appropriate. To avoid the use of small pieces of cut tiles, which are difficult to fix, double tiles, tile-and-a-half or half tiles should be used where available from the manufacturer. Small pieces (less than half tile width) of cut single lap tiles should be bonded or mechanically fixed to the adjoining full-width tile.

NOTE 1 "Perimeter" means the single element (e.g. tile, slate, shingle) at any discontinuity in the plane of the roof, including roof edges.

- c) The more stringent of the following recommendations should be adopted:
 - 1) recommendations for general security against dislodgement, e.g. due to vibration, access traffic (see [5.3.6.2](#) to [5.3.6.13](#)); or
 - 2) fixing recommendations appropriate for the calculated wind loads.

Care should be taken to ensure that the necessary fixing penetration is achieved where the insulation elements are located above the rafter level (see [Annex B](#)).

NOTE 2 Guidance on the use of slate hooks is given in NFRC Technical Bulletin 03 [24].

5.3.6.2 Double-lap tiles

Where nailed, plain tiles should have at least the following fixings.

- a) For nibless tiles, two nails should be used to every tile.
- b) For nibbed tiles, for rafter pitches below 60°, two nails should be used in each tile in at least every fifth course. For rafter pitches of 60° and above, including vertical, two nails should be used in every tile.
- c) At verges and abutments, and at each side of valleys and hips, the end tile in every course should be twice nailed where possible, or mechanically fixed.
- d) At eaves and top edges, two courses of tiles (consisting of under-eaves courses and first full course at eaves, last full course and tops course at top edges) should be nailed or otherwise mechanically fixed.

Nails for plain tiles should be not less than 2.65 mm diameter and of lengths that provide not less than 15 mm penetration into battens.

NOTE Peg tiles and nibless tiles require special treatment. Guidance is given in NFRC Technical Bulletin 07 [25].

5.3.6.3 Single-lap tiles

Single-lap tiles should have at least the following fixings.

- a) For all roof areas and rafter pitches, every tile should be mechanically fixed.

NOTE 1 If the calculation in [Annex H](#) shows that no fixing is required, it is still necessary to provide at least one fixing per tile as a minimum.

- b) For rafter pitches of 45° and over, each tile should be nailed with at least one nail. Additionally, for rafter pitches of 55° and over, including vertical, the tail of each tile should be mechanically fixed.
- c) At verges and abutments, and at each side of valleys and hips, the end tile in every course should be mechanically fixed.
- d) At eaves and top edges, one course of tiles should be mechanically fixed.

Nails for single-lap tiles should be of a length to provide adequate resistance to wind uplift, subject to a minimum penetration of 15 mm, and of a diameter such that the nail is no closer than $5d_n$ to the edge of the tiling batten.

NOTE 2 The presence of nail holes reduces the effective lap of some patterns of tiles. Accordingly, tiles for low pitches are often designed for fixing by nibs and clips. Such clips are usually fixed at or near the tail of the tile and connected to battens or boarding.

Where a tile has two nail holes and is fixed with a single nail, the nail hole nearest to the over-lock (typically the right-hand nail hole) should be used.

5.3.6.4 Double-lap slates, stone slates or artificial slates

Double-lap slates should have minimum fixings of two nails to every slate when centre-nailed. Nails should be of a diameter and length appropriate to the thickness of the slates held down and the position of the slates on the roof.

For natural slates and stone slates the head diameter should be not less than 10 mm.

For fibre-cement slates the shank diameter should be not less than 2.65 mm. For other proprietary materials the diameter and length should be as recommended by the manufacturer.

NOTE 1 Most types of double-lap fibre-cement slates are additionally held together by a copper disc rivet connecting the tail on the centre-line of the slate to the two slates below through the gap between them. The wind uplift resistance of the tail rivet is normally not taken into account.

The length of slate nails should provide a minimum of 15 mm penetration into the batten.

Calculations should be carried out to determine the required penetration of the nails or fixings into the batten, based on the thickness of the slate being used and uplift loading on the roof for the given location of the building.

Centre-nailed slates usually require longer nails near the eaves due to the greater thickness of slate. Where there is a gap between slate and batten, such as when a tilt is provided at the eaves, longer nails should be used unless thicker battens are used to take up the gap between slate and batten. Nail lengths in such cases should generally be equal to the sum of the calculated batten penetration, twice the slate thickness and any gap between the slates and the batten. Thin packing should not be used to fill the gap between the slates and the battens, because they might split and as a result reduce the nail withdrawal resistance.

Hooks for fixing slates should be in accordance with [5.3.6.13](#), with the hook engaging the centre of the tail of the slate.

Slating should be secured against lateral drift (the tendency of the slates to move along the batten under fluctuating wind loads) by nailing or mechanically fixing the end slates in each course.

Hooks with crimped shanks reduce the capillary rise of water at the perpendicular joints between slates and are suitable for all roof pitches between 25° and 90°. Straight shank hooks should not be used at roof pitches below 30°. Hooks should not be used at roof pitches below 25°.

When using hooks at roof pitches greater than 75°, special design considerations apply and specifiers and designers should consult the slate manufacturer or supplier for specific guidance. Slates sized at 500 mm × 250 mm or less are generally used as they apply less uplift force to the hooks.

NOTE 2 The use of hooks is limited by the increased water penetration and wind uplift that occur at lower pitches. Additionally, lower pitches require the use of larger slates to resist water penetration. These in turn exert larger uplift forces on the hooks than smaller slates.

NOTE 3 The use of hooks does not eliminate the necessity to sort natural slates by thickness.

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.

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, therefore they should be thick enough to provide the necessary resistance to the uplift force.

NOTE 4 Head nailing or 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. Guidance on head-nailing and shoulder-nailing of slates in Scottish practice is given in NFRC Technical Bulletin 43 [26].

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

NOTE 5 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. Further guidance is given in NFRC Technical Bulletin 43 [26].

Slates for vertical work should preferably be centre-nailed to eliminate the tendency of head-nailed slates to rattle in the wind.

5.3.6.5 Bitumen shingles

For bitumen shingles, the manufacturer's instructions on minimum and wind resistance fixings should be followed. Evidence should be sought from the manufacturer that the wind uplift resistance has been shown to be satisfactory for not less than 15 years for the appropriate site exposure conditions in the UK (this could be in the form of evidence from an appropriate test method that can be directly correlated with the recommended conditions of use).

NOTE Bitumen shingles are usually supplied in short lengths, which are nailed to boarding and glued to each other by intermittent self-adhesive strips across the centre of the shingle elements.

5.3.6.6 Wooden shingles and shakes

In addition to checking for resistance to wind uplift, wooden shingles or shakes should be fixed in accordance with the manufacturer's recommendations.

NOTE Further guidance is given in NFRC Technical Bulletin 34 [N1].

5.3.6.7 Metal tiles

In addition to checking for resistance to wind uplift, metal tiles should be fixed by either nails or screws upslope through the upstand of the head-lap into the side of the batten, and vertically through the upper face at the tail of the tile into the batten at the eaves course. The manufacturer's recommendations for minimum fixings should be followed.

5.3.6.8 Underlays, sarking and battens

In addition to checking for resistance to wind uplift, the nailing for sarking boards and battens for general security should be at least one round steel wire nail (or two nails in the case of a butt joint) of 3.35 mm diameter and a penetration of not less than 40 mm.

Battens and counterbattens fixed to masonry should be plugged or shot-fired with connections of proven adequate pull-out resistance. Cut nails driven into masonry should only be used when loaded in shear and not when loaded in withdrawal.

Nails for use with roofing underlays should be clout head-nails of not less than 3.0 mm shank diameter and 20 mm length in accordance with [4.12.1.2](#).

Proprietary fixings for use with sarking boards, underlays, battens and counterbattens should be durable and capable of resisting the dead loads, snow loads, wind loads and imposed loads applicable to the roof and its location (see also [5.2.1](#), [5.2.2](#), [5.2.3](#), [5.2.4](#), [5.3.2](#), [Annex B](#) and [Annex H](#)).

5.3.6.9 Flashings

Flashings should be installed in accordance with [4.13](#) and the manufacturer's recommendations.

5.3.6.10 Fittings and accessories

In addition to checking for resistance to wind uplift and differential movement, the fixings used for both mortar-bedded and dry fixed ridges and hips should be of proven durability and used in accordance with the manufacturer's recommendations.

5.3.6.11 Spacing of nails and screws

To minimize timber splitting, nails and screws in timber-to-timber joints should be positioned with the minimum spacing as a multiple of the nail diameter d_n or screw diameter d_s (see [Table 7](#)).

Table 7 — Minimum spacing of nails and screws

Spacing	Without pre-drilled holes	With pre-drilled holes
Edge distance	$5d_n$ or $5d_s$	$5d_n$ or $5d_s$
End distance ^{A)}	$20d_n$ or $20d_s$	$10d_n$ or $10d_s$

^{A)} Where it is impractical to meet the recommendations for end distances (such as when nailing butt joints of battens to rafters), opposed double skew nailing should be used.

5.3.6.12 Clips

All clips should have adequate resistance to the calculated wind uplift loads, and should allow the roofing element to return to its laid position after maximum wind load events. When calculated in accordance with [Annex I](#), the design value of the fastener uplift resistance, R_c , should be not less than the design value of the force applied by the tile clip to resist wind uplift, F_c .

NOTE See also BS EN 14437 for the determination by testing of the uplift resistance of concrete and clay tiles.

5.3.6.13 Hook fixings for slates

Hooks for fixing slates should be in accordance with [4.12.3](#), having a chisel point for nailing into the batten and a hook engaging the tail of the slate.

When tested in accordance with [Annex J](#), the value of the hook resistance, R_{hk} , should be not less than the value of the uplift force acting on the hook calculated in accordance with [Annex H](#). Hooks should not displace under load to the extent that the wind load on the slate would be significantly increased, nor allow the slate to be displaced to the extent that it would break.

5.4 Rain and snow resistance

5.4.1 General

COMMENTARY ON 5.4.1

The UK has a climate where there is a high risk of severe driving rain.

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;*
- *additional water on roofs with long rafter lengths;*
- *rainwater discharge from an adjacent roof onto the roof covering;*
- *wind-driven snow;*
- *water displaced around roof windows.*

The extent to which a roofing product is 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.

A map of the UK (see [Figure 2](#)) details four categories of exposure, based on driving rain penetration data given in [BS 8104:1992](#) and BR 262 [27]. This map should be used when designing buildings up to 12 m ridge height.

NOTE 1 For more detailed guidance, see [BS 8104:1992](#). For buildings above 12 m in height, the influence of increased wind speed can be determined using BS EN 1991-1-4.

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. PD CEN/TR 15601 may be used as a comparative method of test to determine the resistance to driving rain of roof systems with discontinuously laid small elements.

5.4.2 Roof pitch, head-laps and side-laps

5.4.2.1 Roof pitches

When calculating head-laps and side-laps, the roof pitch should be taken to be equal to the rafter pitch (but see [5.5.4.3](#)).

NOTE The actual pitch of a slate/tile/shingle when laid is less than the roof pitch.

5.4.2.2 Head-laps (double-lap)

Head-laps for double-lap tiles should be not less than that recommended in [5.5.2.1](#).

Head-laps for double-lap slates should be not less than that recommended in [5.5.4.2](#) and [Figure 3](#).

NOTE 1 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 [5.5.5](#) and [5.5.6](#) for shingles and shakes, [5.5.7](#) and [5.5.8](#) for metal tiles and other tiles and slates, [Figure 3](#) and [Figure 4](#) for slates and [Figure 5](#) for double-lap plain tiles).

NOTE 2 Certain types of shingle are laid to a triple lap.

5.4.2.3 Head-laps (single-lap)

Head-laps for single-lap tiles should be not less than that recommended in [5.5.3.1](#).

NOTE 1 The head-lap for single-lap tiles is the distance by which a course of tiles provides an overlap with the next course below (see [Figure 6](#) for single-lap tiles).

NOTE 2 Some single-lap products have a head-lap of fixed dimension resulting from the design of the product.

Figure 2 — UK map of categories of exposure to driving rain



Figure 2 (continued)

	Moderate	$\geq 33 < 56.5$
	Severe	$\geq 56.5 < 100$
	Very severe	100

NOTE 1 Derived from BS 8104:1992 and BRE 262 [27].

NOTE 2 For the Scilly Isles and Channel Islands, assume $100 \text{ } \langle A_2 \rangle \text{ l/m}^2 \text{ } \langle A_2 \rangle$ per spell.

NOTE 3 Driving rain exposures of $< 56.5 \text{ } \langle A_2 \rangle \text{ l/m}^2 \text{ } \langle A_2 \rangle$ per spell and $\geq 56.5 \text{ } \langle A_2 \rangle \text{ l/m}^2 \text{ } \langle A_2 \rangle$ per spell apply to head-lap calculations for nail-fixed or hook-fixed double-lap fibre-cement and natural slates (see 5.5.4, Table 8 and Table 9).

Figure 3 — Laps for centre-nailed, head-fixed and shoulder-fixed double-lap slates

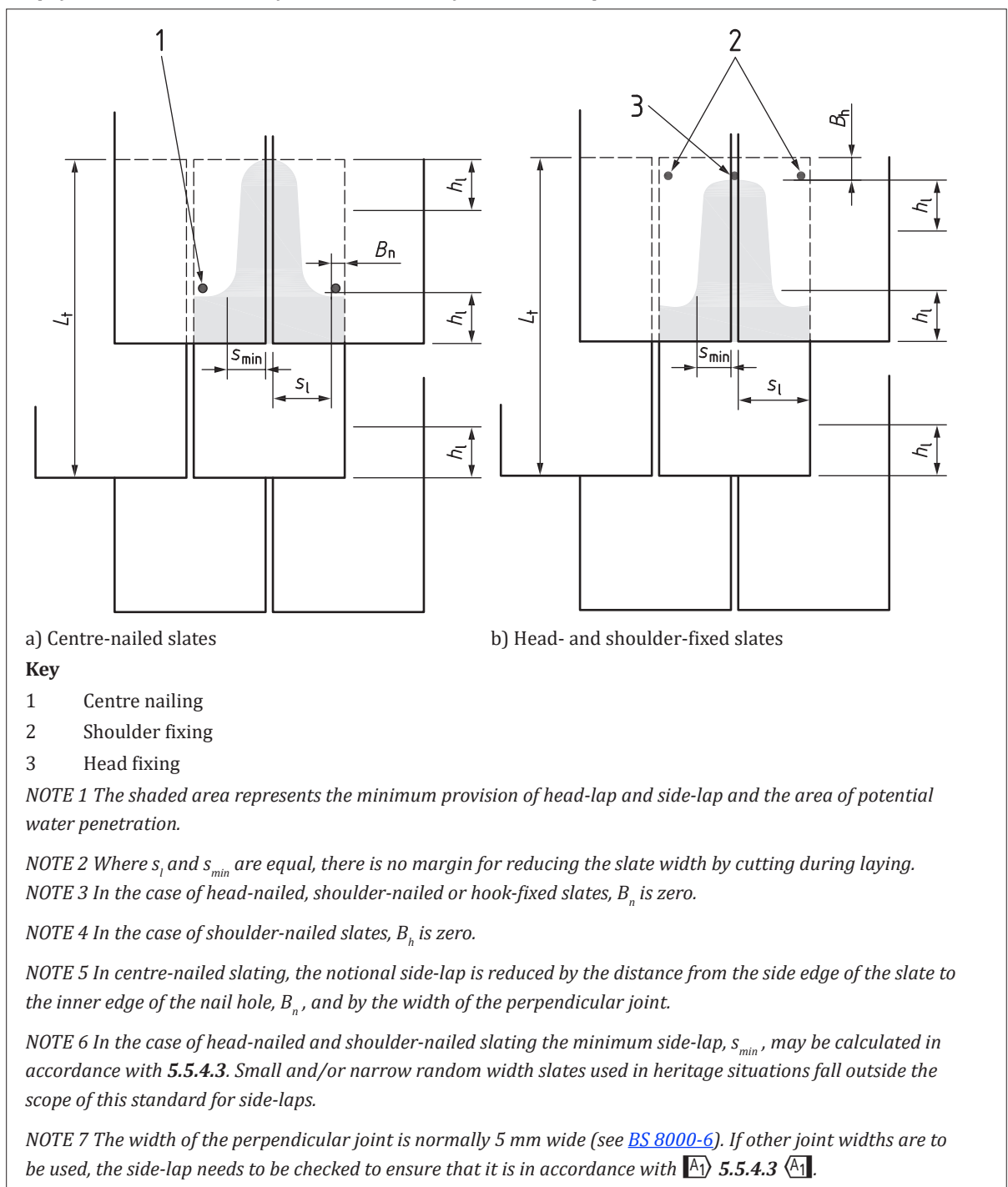
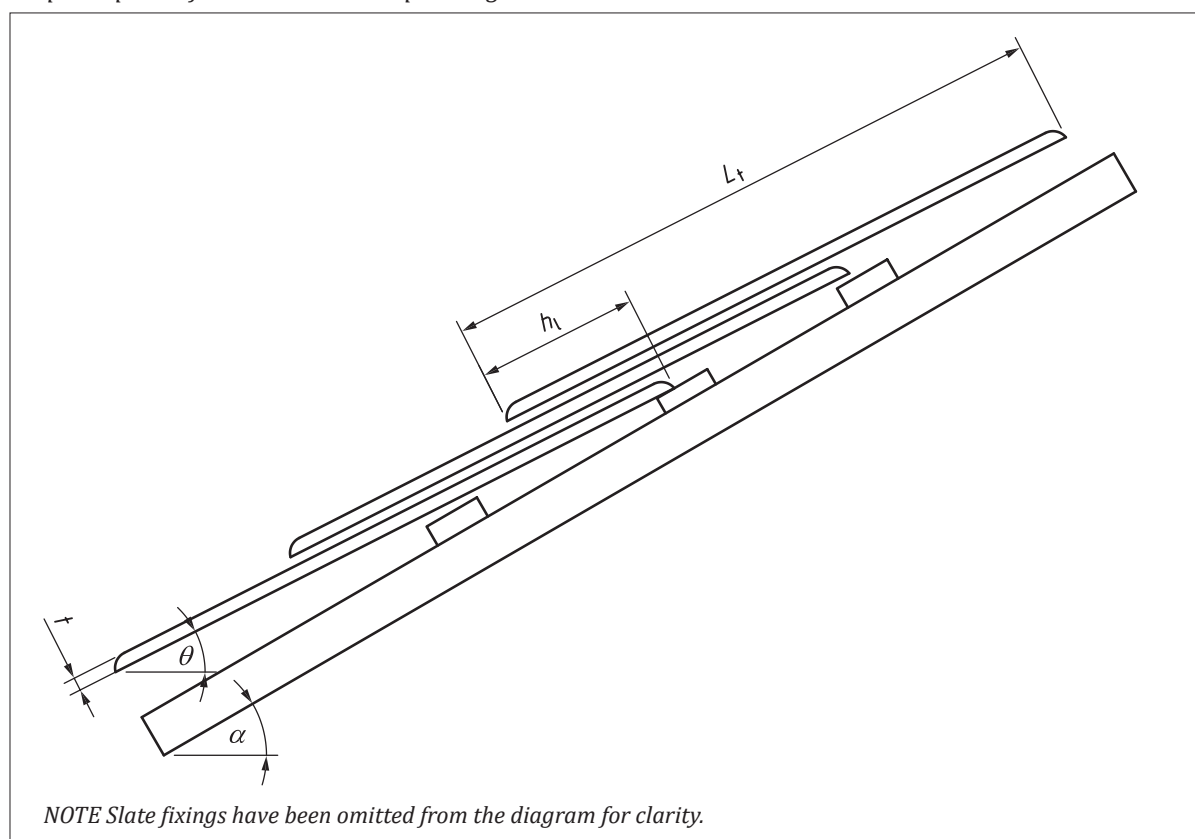


Figure 4 — Lap and pitch of slates in double-lap slating**5.4.2.4 Side-laps (double-lap)**

NOTE 1 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 [5.5.4.3](#) for the relevant driving rain exposure category.

NOTE 2 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.

5.4.2.5 Side-laps (single-lap)

The side-lap for single-lap tiles should be in accordance with [5.5.3.2](#).

NOTE 1 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 (see [Figure 6](#)).

NOTE 2 Single-lap interlocking tiles generally have a proprietary side-lock design.

Figure 5 — Lap and pitch of tiles in double-lap plain tiles

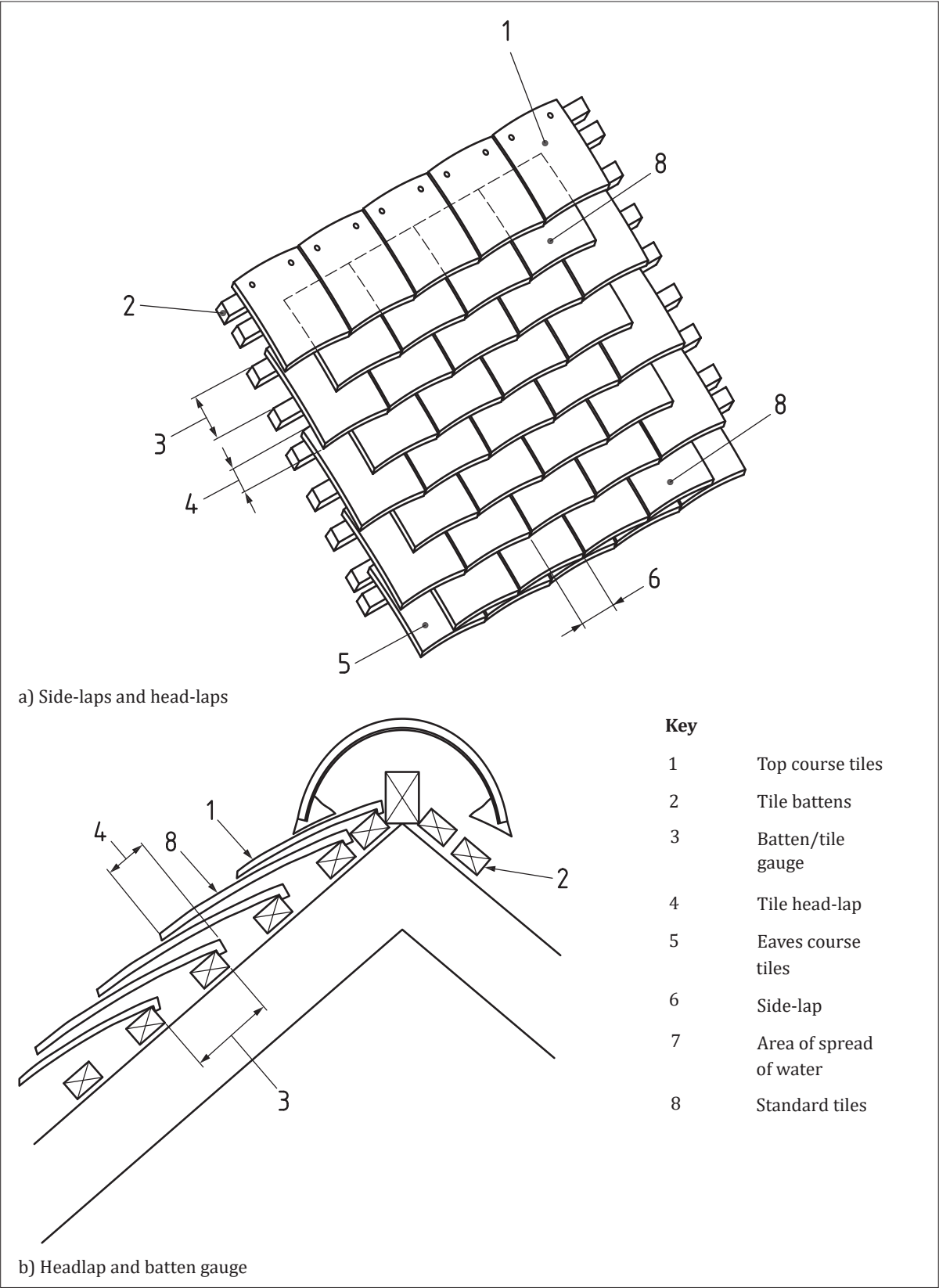


Figure 5 (continued)

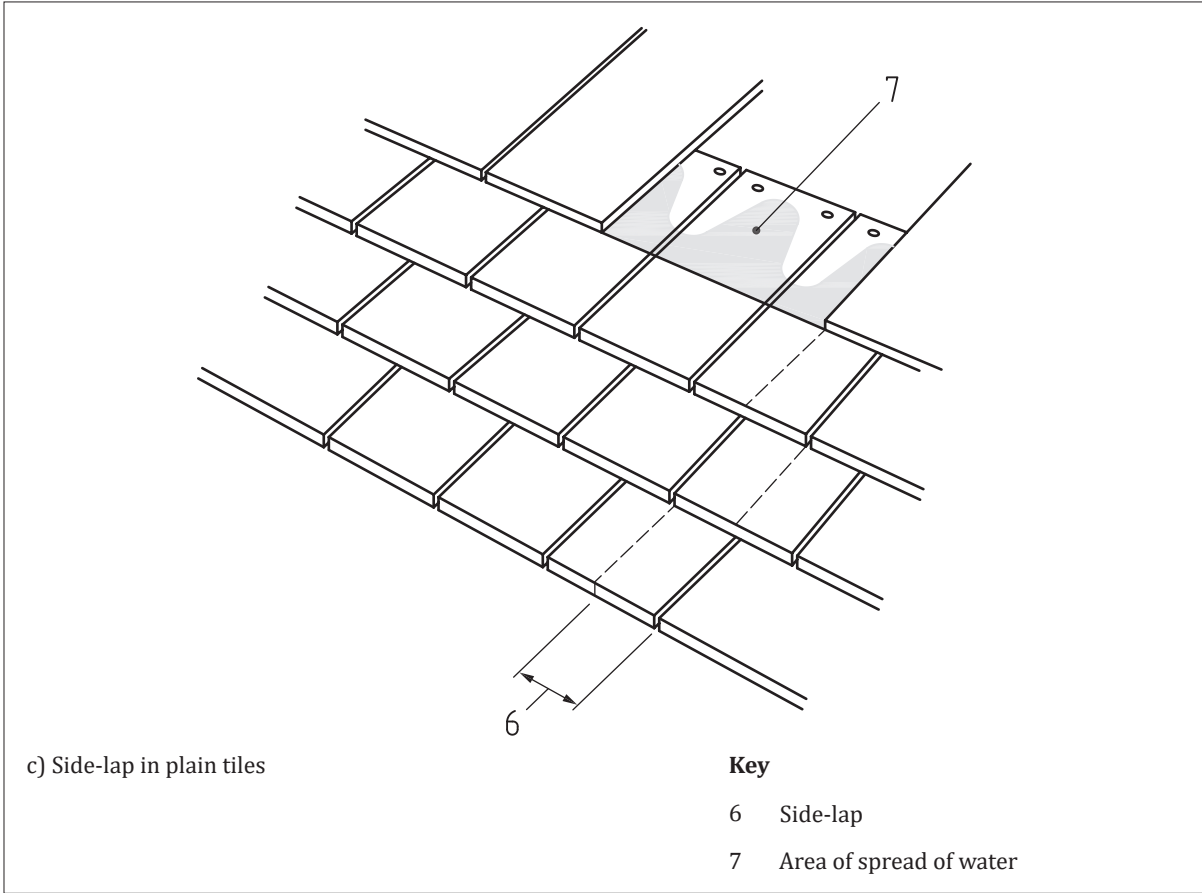


Figure 6 — Lap and pitch of tiles in single-lap tiles

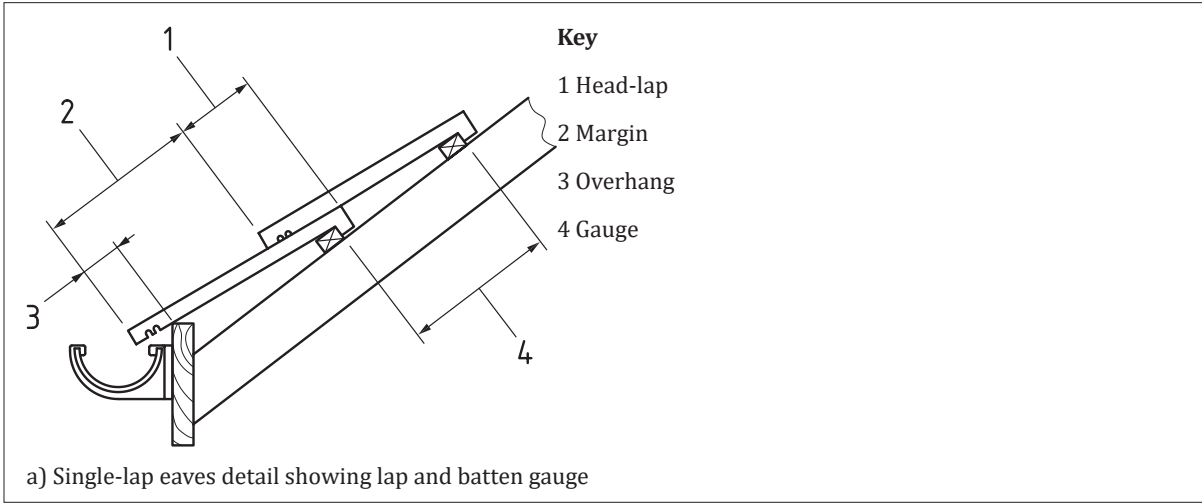
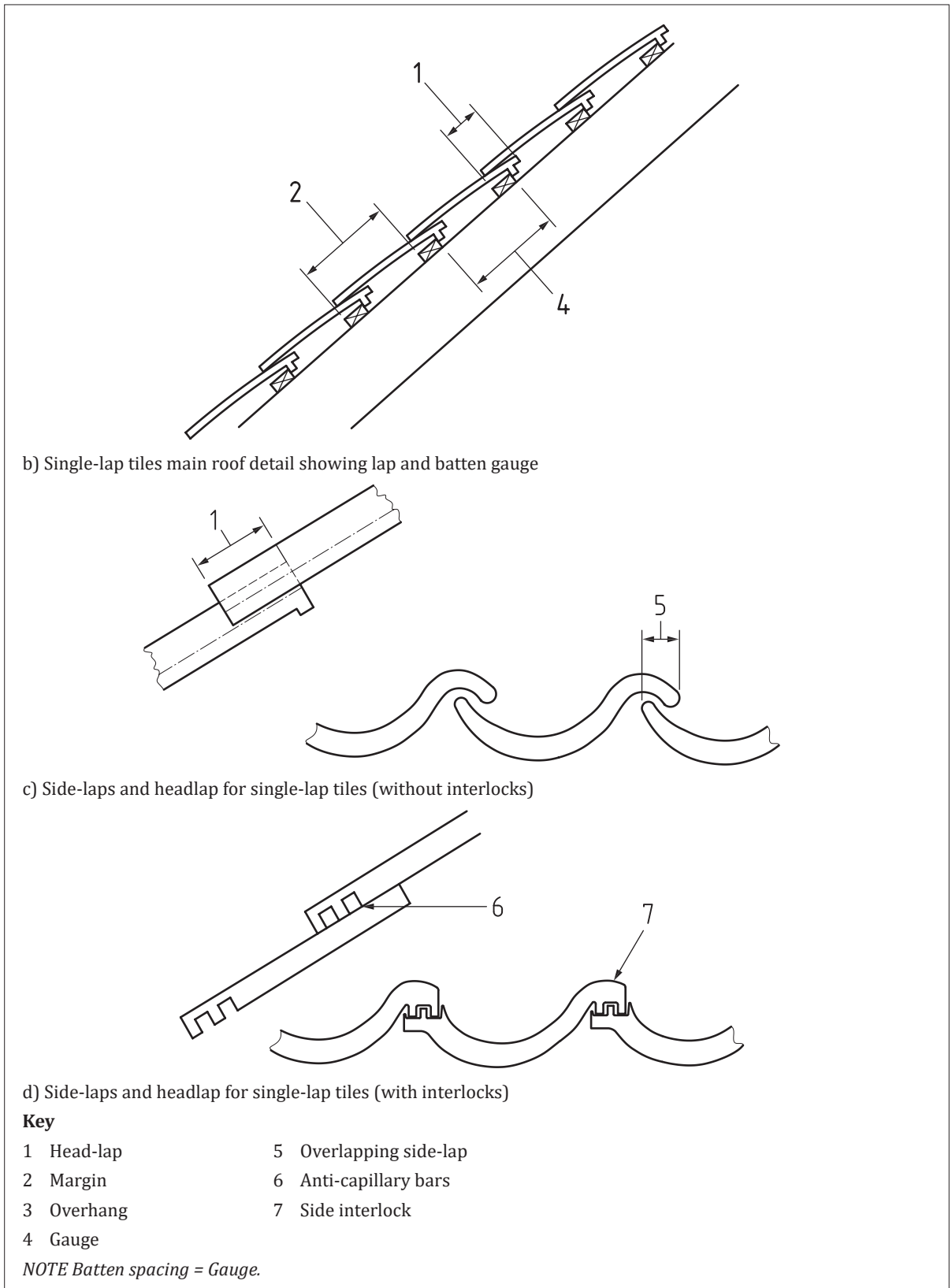


Figure 6 (continued)

5.4.2.6 Double-lap slates

5.4.2.6.1 General

The head-laps and side-laps that should be used in double-lap slating depend on the method of fixing adopted.

Fibre-cement double-lap slates greater than 400 mm × 200 mm should be fixed with nails and have a rivet at the tail or hook fixed in accordance with [5.3.6.4](#), [5.3.6.13](#) and [5.4.2.6.3](#).

NOTE All double-lap slates may be centre-nailed or hook fixed. Natural double-lap slates may also be nailed or pegged at the head or the shoulders of the slate (see [5.4.2.6.4](#), [5.4.2.6.5](#) and NFRC Technical Bulletin 43 [26]).

5.4.2.6.2 Centre-nailed slates

Centre-nailed, double-lap slates should be 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 [5.5.4.3](#).

In centre-nailed slating, the gauge is the spacing at which battens are fixed to the rafters, trusses or counterbattens 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), should be calculated using equation (1).

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

5.4.2.6.3 Hook-fixed slates

Hooked double-lap slates should be 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 [4.12.3.2](#) and [Annex K](#)). When hook fixing, a minimum of two nail fixings in addition to the hooks or other fixings recommended by the manufacturer should be used at eaves, ridges and top abutments and, to prevent lateral drift, at verges, hips, valleys and side abutments.

NOTE 1 The dimension B_n is treated as being zero in hook fixing, so it is not necessary to take it into account when calculating side-laps (see [Figure 3](#)).

NOTE 2 The use of hooks is limited by the increased water penetration and wind uplift that occur at lower pitches. Additionally, lower pitches require the use of larger slates to resist water penetration. These in turn exert larger uplift forces on the hook than smaller slates.

5.4.2.6.4 Head-fixed slates

Head-fixed slates should be fixed centrally at the head of each slate by a single peg or a single nail. In this case the head-lap should be 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 (see also [Figure 3](#)).

NOTE Because the position of the nail or peg holes, the dimension B_n is treated as being zero in head-nail fixing, and so it is not necessary to take it into account when calculating side-laps (see [Figure 3](#)).

5.4.2.6.5 Shoulder-fixed slates

Shoulder-fixed slates should be fixed with two nails or pegs near to the top corners of the slates as laid, outside the area of water spread. In this case the head-lap should be 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.

NOTE 1 Because the position of the nail or peg holes, the dimensions B_h and B_n are treated as being zero in shoulder-nail fixing, and so it is not necessary to take it into account when calculating head-laps and side-laps (see [Figure 3](#)).

NOTE 2 Further guidance on head-fixing and shoulder-fixing slates in Scottish practice is given in NFRC Technical Bulletin 43 [26].

5.5 Minimum pitch, head-laps and side-laps for roofs

5.5.1 General

The recommendations for minimum pitches and laps for slate and tile products apply to normal situations. The specifier should also take account of any local or regional climatic conditions that might apply, which might necessitate greater values than the recommended minima. If it is necessary to use products at pitches lower than the recommended minima, e.g. due to the design requirements of the roof, special precautions should be taken to prevent the ingress of rainwater through the external layer of slates, tiles or shingles by the provision of a functional weatherproof sub-roof system (see [5.5.9](#)).

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 recommendations in [5.5.2](#) to [5.5.6](#) for pitches and laps do 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.

Generally, the recommendations for slates should be followed for rafter lengths of not more than 9 m in driving rain exposures of less than $56.5 \frac{\text{A}_2}{\text{m}^2}$ per spell and 6 m in driving rain exposures of $56.5 \frac{\text{A}_2}{\text{m}^2}$ per spell or greater (see [5.5.4](#)).

In special forms of slating and double-lap tiling, such as for random slate or conical roofs where the slate or tile widths are variable, the minimum head-laps and side-laps should be calculated in accordance with [5.5.2](#) and [5.5.4](#). For conical roofs where the slates and tiles are tapered in their length, the applicable width should be taken as the width at the head of the slate or tile.

Where traditional single-lap tiles (interlocking) are to be specified, the pitches, head-laps and side-laps should be in accordance with [5.5.3](#).

Where proprietary single-lap (interlocking) 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 PD CEN/TR 15601 may be used as a comparative method of test to determine the resistance to driving rain of roof systems with discontinuously laid small elements.

5.5.2 Double-lap clay and concrete plain tiles

5.5.2.1 Head-lap

The head-lap of plain tiles should be not less than 65 mm and should not exceed one-third of the length of the tile (see [Figure 5](#)). For feature and ornamental tiles, the shape of the tail should be taken into account 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.