

Code of practice for

Slating and tiling (including shingles)

Part 1. Design

ICS 91.060.20

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/542, Roofing and cladding products for discontinuous laying, to Subcommittee B/542/1, Slating and tiling, upon which the following bodies were represented:

- Association of Building Engineers
- Association of British Roofing Felt Manufacturers
- Association of Building Component Manufacturers
- British Precast Concrete Federation Ltd.
- Building Employers' Confederation
- Clay Roofing Tile Council
- Concrete Tile Manufacturers' Association
- Department of the Environment (British Board of Agrément)
- Department of the Environment (Building Research Establishment)
- Fibre Cement Manufacturers' Association
- Health and Safety Executive
- Institute of Building Control
- Metal Cladding and Roofing Manufacturers' Association
- National Federation of Roofing Contractors
- National House-building Council
- Natural Slate Quarries Association
- Royal Institute of British Architects
- Timber Research and Development Association
- Timber Trade Federation
- Union of Construction, Allied Trades and Technicians
- Wood Panel Industries Federation

This British Standard, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 September 1997

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Amendments issued since publication

Amd. No.	Date	Text affected

The following BSI references relate to the work on this standard:
Committee reference B/542/1
Draft for comment 93/106962 DC

ISBN 0 580 27697 X

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Foreword

This British Standard has been prepared by Subcommittee B/542/1. This Part of BS 5534 replaces BS 5534 : Part 1 : 1990 and BS 5534 : Part 2 : 1986, which are withdrawn. The standard was first published as CP 142 in September 1942, revised in January 1958 and April 1968 and converted into a metric version giving values in SI units in October 1971. It was first published as BS 5534 : Part 1 in April 1978.

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

Clauses have been introduced to reflect the wider range of slating/tiling products now in use and to accommodate the requirements of the Construction Products Regulation 1991 [1].

Section 3, which deals with recommendations for design, has been revised to reflect the new knowledge and experience on rain resistance and wind load resistance.

Where reference is made to proprietary products and to manufacturers' recommendations, the specifier should satisfy himself that these products and recommendations have been proven by relevant experience or relevant test method data based on the conditions of use and methods of use in the UK climate.

It is advisable that the designer or specifier seeks assurances at the design stage of a project that such recommendations are appropriate and that adequate quality assurance schemes such as BS EN 9001, BS EN 9002 and BS EN 9003 are used for all roofing products, fittings and accessories.

Recommendations for workmanship for slating/tiling are given in BS 8000 : Part 6.

NOTE. As a code of practice, this Part of BS 5534 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.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 76, an inside back cover and a back cover.

Section 1. General

1.1 Scope

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

This code of practice does not deal with workmanship requirements which are included in BS 8000 : Part 6. It does not deal with designs and application techniques developed to satisfy a specific local need e.g. curved roofs and random slating.

1.2 References

1.2.1 Normative references

This Part of BS 5534 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on page 75. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this Part of BS 5534 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

1.2.2 Informative references

This Part of BS 5534 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page 76, but reference should be made to the latest editions.

1.3 Definitions

For the purposes of this Part of BS 5534, the definitions given in 3.1, BS 6100 : Subsection 1.3.1 and BS 6100 : Subsection 1.3.2 apply.

1.4 Symbols

For the purposes of this Part of BS 5534, the symbols given in 1.4.1 and 1.4.2 apply.

1.4.1 This Part of BS 5534 derives data from BS 6399 : Part 2, and the following symbols have been adopted from that standard.

V_e	effective wind speed (in m/s)
q_s	dynamic pressure of standard method (in N/m ²)
C_{pe}	external pressure coefficient
L	building length (in m)
H	building height (in m)
W	building width (in m)
α	pitch angle (from the horizontal) of the roof (in °)

1.4.2 The following symbols are specific to this Part of BS 5534.

NOTE. Additional symbols used only in the annexes are defined in the annexes, where appropriate.

a	mortar contact surface area (in mm ²)
A	valley width (in mm)
A_{bo}	overhang at verge (in m)
A_t	exposed area of a roofing element (in m ²)
$A_{o,e}$	exposed overhanging area of roofing element at eaves (in m ²)
$A_{t,e}$	exposed area of part of roofing element at the eaves that is protecting the underlay (in m ²)
$A_{o,v}$	exposed overhanging area of roofing element at verge (in m ²)
$A_{t,v}$	exposed area of part of roofing element at the verge that is protected by underlay (in m ²)
A_{tr}	vertically projected area of a ridge or hip tile (in m ²)
A_h	horizontally projected area of a ridge or hip tile (in m ²)
B	cover width of a roofing element (in m)
B_n	distance from nail hole to the side edge of a slate (in m)
B_o	overhanging length of a roofing element (in m)
B_r	length of a ridge or hip tile (in m)
C_{pt}	pressure difference coefficient
C_{pi}	internal pressure coefficient
D	air permeability factor
F_h	horizontal wind shear force on the ridge/hip tiles (in N)
F_t	wind uplift force on the exposed area of the tile/slate (negative values denote uplift) (in N)
$F_{o,e}$	wind uplift force on the non overhanging part of the exposed area of the tile/slate (negative values denote uplift) (in N)
F_{tr}	wind uplift force on a ridge or hip tile (negative values denote uplift) (in N)
F_c	force on the tile clip to resist wind uplift (in N)
F_o	wind uplift force on the overhanging part of the exposed area of the slate/tile (negative values denote uplift) (in N)
g	acceleration due to gravity (9.81 m/s ²)
G_a	batten gauge (in m)
G_d	general roof areas for duopitch and hipped roofs (in m ²)
G_m	general roof areas for monopitch roofs (in m ²)
h_r	height of ridge or hip tile (in m)
H	height (in m)

H_i	inner hip local roof areas for duopitch and hipped roofs (in m)
K	pressure drop coefficient
k_n	nailing factor (used for nailing an occasional course of tiles)
l	length (parallel to the rafters) of local roof areas (in m)
L_d	other local areas and valleys for duopitch and hipped roofs (in m)
L_o	overhanging length (up the rafter line) of a tile/slate (in m)
L_s	hanging length less the batten gauge (in m)
L_m	all local roof areas and valleys for monopitch roofs
L_n	lever arm of nail (in m)
L_f	uplift force lever arm (in m)
L_r	width of a ridge or hip tile (in m)
L_h	hanging length of a roofing element (in m)
L_v	the exposed width of a valley (in m)
n	number of courses of roofing elements held down by one nailed course
p_c	critical upward pressure difference (in N/m^2)
p_u	pressure acting on the underlay (in N/m^2)
R	uplift pressure reduction factor
R_c	clip resistance against uplift (in N)
R_i	inner ridge local roof areas for duopitch and hipped roofs (in m^2)
R_n	required nail resistance (in N)
R_s	rafter spacing (in m)
S	roof substrate shielding factor
S_m	failure load (in N)
S_n	test values of mortar strength (in N/mm^2)
S_t	mortar tensile adhesion strength (in N/mm^2)
w	width (parallel to the battens) of local roof areas (in m)
W'	weight of roofing elements (in N/m^2)
W_p	restoring force due to weight perpendicular to the roof plane (in m)
X, Y and Z	dimensions of a roof obstruction (in m)
x and y	dimensions of the local area surrounding a roof obstruction (in m)
w_t	self-weight of a roofing element (in kg)
θ	angle of the roofing element from the horizontal (in $^\circ$)
ϕ	angle of creep on slates (in $^\circ$)

Section 2. Materials, fittings and accessories

NOTE. Users of this Part of BS 5534 should also refer to accreditation certificates and manufacturers' technical data relevant to the conditions of use in the UK.

2.1 Clay tiles and fittings (single and double lap)

2.1.1 Single lap tiles (fixed and variable gauge)

There is no British Standard for single lap tiles. Clay single lap tiles and fittings should conform to the frost test given in BS 402 : Part 1.

2.1.2 Double lap plain tiles

Double lap clay tiles and fittings should conform to the recommendations given in BS 402 : Part 1.

NOTE. ENs for clay roofing tiles are in preparation.

2.2 Concrete tiles and fittings (single and double lap)

Concrete tiles and fittings should conform to the recommendations given in BS EN 490 and BS EN 491.

2.3 Fibre-cement slates and fittings

Fibre cement slates should conform to the recommendations given in BS EN 492. All fibre cement fittings should conform to the relevant quality and durability recommendation given in BS EN 492.

NOTE. Health and Safety precautions are necessary when working with asbestos cement products i.e. fibre cement products containing asbestos fibres which should be identified as chrysotile. See also 3.13.

2.4 Natural slates and fittings

Natural slates should conform to the recommendations given in BS 680.

NOTE. An EN for natural slates is in preparation.

2.5 Bitumen shingles

There is no British Standard for bitumen shingles.

NOTE. An EN for bitumen roofing shingles is in preparation.

2.6 Wooden shingles and shakes

There is no British Standard for wooden shingles and shakes. Wooden shingles and shakes should be suitably treated to provide enhanced durability. See 3.7.5.2.

2.7 Metal tiles

There is no British Standard for metal tiles. Metal tiles should be manufactured from corrosion resistant metals or metals of adequate strength, suitably treated to provide durability. See 3.7.2.4.

2.8 Other tiles and artificial slates

Proprietary tiles and artificial slates which include composite, resin filled, bonded or lightweight products, etc. (outside the scope of the relevant tile, slate or shingle British Standards) should be of adequate strength, water impermeability, durability, geometric dimensions and tolerances.

2.9 Valley units (pre-formed)

Proprietary valley units which include pre-formed GRP, PVC-U and metal products, etc. should be of adequate strength, water impermeability, durability and geometric dimensions.

2.10 Roofing underlay

2.10.1 General

The roofing underlay provides a barrier to minimize the wind load generated under wind gusts acting on slates and tiles. It also provides a barrier to prevent wind driven snow or dust from entering the roof space and transports any rainwater which may penetrate the slates or tiles into the roof drainage system.

NOTE. An EN for roofing underlay is in preparation.

2.10.2 Fully supported

NOTE. This includes roofing underlays laid directly onto the boarding or sarking.

The roofing underlay should be of adequate strength, water resistance and durability with water vapour transmission high enough to prevent the formation of condensation beneath the underlay. A test carried out in accordance with BS 3177 is recommended with a minimum permeability of 0.36 g/m² per 24 h at 25 °C and a relative humidity of 75 %. The method of assessment given in BS 5250 should be used to ensure that harmful condensation will not develop. If necessary, to overcome potential condensation risks, a vapour control layer should be incorporated within the structure.

2.10.3 Unsupported

NOTE. This includes roofing underlays which are draped over the rafters or underlays laid over counter-battens on boarding or sarking.

Roofing underlay should be of adequate water resistance and of tensile and nail-tear strength, low extensibility under the roof environment to produce the required resistance to wind uplift. It should conform to the requirements for type 1F or 5U given in BS 747. Other roofing underlays which satisfy these recommendations may also be used.

NOTE. Refer also to NFRC Technical Bulletin No. 6 [2].

2.10.4 Other types

Proprietary roofing underlays which have adequate strength, water resistance, nail-tear resistance, water vapour resistance (where required) and durability and do not adversely affect the laying and performance of the roofing products may also be used.

NOTE. Refer also to NFRC Technical Bulletin No. 6 [2].

2.11 Boarding, sheathing and sarking

Boarding, sheathing and sarking should be either tongued and grooved or square-edged. Tongued and grooved boarding should conform to BS 1297.

Plywoods should be selected from those listed in BS EN 635, BS EN 313-1 and BS EN 313-2 and BS 5268 : Part 2.

Woodwool slabs should conform to BS 1105.

Fibreboards should conform to the recommended types for sarking and sheathing given in BS 1142.

Particle boards, type C3, C4 or C5 wood chipboard should conform to BS 5669 : Part 2 and BS EN 311.

Orientated strand board type F2 should conform to BS 5669 : Parts 3 and 5.

Cement bonded particleboard should conform to BS EN 634-1 and BS 5669 : Parts 4 and 5.

Other manufactured boards of adequate strength, durability and performance may also be used.

NOTE. Other ENs for wood based products suitable for use as boarding/sheathing and sarking are in preparation.

2.12 Battens and counterbattens

2.12.1 Timber species

Timber battens and counterbattens should be of the following species:

Type A: Imported Whitewood
Imported Redwood
Canadian/USA Spruce-pine-fir
USA Southern Pine

Type B: British-grown Corsican Pine
British-grown Scots Pine
British-grown Sitka Spruce

NOTE. For the purposes of this Part of BS 5534, 'British-grown' species are those grown in the United Kingdom and the Irish Republic.

2.12.2 Permissible characteristics and defects

Characteristics and defects in timber battens should not exceed the limits given in annex E.

2.12.3 Preservative treatment

It is not essential to treat tiling or slating battens with a preservative except as required by the building regulations and by-laws in areas subject to attack by the House Longhorn beetle. Impregnation with preservative should be considered in cases where maximum durability is sought or where there is a high risk of condensation or lack of ventilation.

NOTE 1. Attention is drawn to the risk of chemical attack by certain types of preservative treatments on certain metal fittings and fasteners (see 3.7). Preservative treatment compositions should satisfy the schedules or immersion periods in accordance with annex F.

NOTE 2. It is also good practice to treat the cut ends of battens at the verge.

NOTE 3. Consideration should be given to the safe disposal of battens treated with preservatives as they may contain toxic substances which could introduce an environmental hazard.

NOTE 4. Care should be taken to avoid contact between some metal-based mechanical fixings or metal flashings and/or some other metal products with some preservative treated timber types which may result in galvanic corrosion when moisture is present.

NOTE 5. Information may be obtained from the British Wood Preserving and Damp-proofing Association.

2.12.4 Recommended batten sizes

The following should be considered in determining batten sizes.

- a) Recommended timber batten sizes for various common applications are given in table 1, subject to permissible tolerances given in Note 1 of the table.
- b) Battens of other sizes may be designed in accordance with the recommendations of annex G and annex H by structural calculation for strength and stiffness. The basic sizes so determined are subject to the same tolerances on depth and width given in table 1 and permissible characteristics and defects given in annex E.
- c) Generally, batten lengths should be sufficient to span over not less than three consecutive supports.
- d) Battens fixed parallel to the rafters for under-and-over tiles should be of adequate size to suit the tile used. These battens should be chamfered to provide a bed for the undertile.

2.12.5 Identification

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

- a) name of supplier;
- b) timber species type or the actual species, from types A or B, graded as recommended in this Part of BS 5534;
- c) basic size or sizes;
- d) type of preservative and method of treatment, if applicable.

NOTE. Refer also to NFRC Technical Bulletin No. 15 [3].

Table 1. Recommended timber batten sizes (roofing and vertical work)

Application	Basic size of batten			
	450 mm span		600 mm span	
	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
NOTE 1. Tolerances on the basic sizes of timber batten should be: Width +3 mm or -3 mm; depth -0 mm or +3 mm; based on measurement at a reference moisture content of 20 % (see annex E).				
NOTE 2. Where a batten is continuously supported directly by board sarking which itself is capable of supporting the roof imposed concentrated load (e.g. in Scottish practice), battens should be of a minimum basic cross-section size of 38 mm × 19 mm.				
NOTE 3. Span is defined as the distance between centres of supports, or the clear distance between the face of supports plus half the bearing length at each end support, whichever is the lesser. The minimum end bearing length should be 17.5 mm.				
NOTE 4. Batten span 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 manufacturers' recommendations and Agrément Certificates where relevant.				
NOTE 5. Batten sizes other than those given in table 1 should be designed by structural calculation in accordance with annex H and annex G for strength and stiffness. When determining batten sizes, consideration should also be given to adequate dimensions for nailing and using commercially economic sizes.				

2.13 Mechanical fixings

2.13.1 Nails: general

Nails are the most common form of fixing and it is recommended that nails intended for use as fixings should conform to the relevant Parts of BS 1202, i.e.

for aluminium nails: see BS 1202 : Part 3;
 for copper nails: see BS 1202 : Part 2;
 for steel nails: see BS 1202 : Part 1.

Or be as follows:

for silicon-bronze nails use the manufacturers' specification;
 for zinc-coated nails hot-dipped, galvanized and sherardized;
 for nails made of other materials use manufacturers' specification.

NOTE. An EN for nails and staples for use in timber is in preparation.

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

2.13.2 Nails for battens, counterbattens, boarding and roofing underlays

2.13.2.1 General

Recommendations for the use of nails on battens, counterbattens, boarding and roofing underlays are given in 2.13.2.2 to 2.13.2.4.

2.13.2.2 Battens and counterbattens

Nails intended for use with battens and counterbattens should be as defined in BS 1202 : Part 1, round wire nails of 3.35 mm shank diameter. Annular ring shank or helical threaded shank nails may also be used. For extra protection and in coastal regions the steel nails should be hot-dipped galvanized or sherardized. The length and type of nail to be used should depend on the exposure of the site (see 3.6.2.7). Special nails should be used for masonry wall applications.

2.13.2.3 Boarding

Nails intended for use with boarding should be as defined in BS 1202 : Part 1, round wire nails of 3.35 mm shank diameter, oval brad head, or cut floor brads, with a minimum of 40 mm penetration into the supporting element.

2.13.2.4 Roofing underlays

Nails intended for use with roofing underlays should be extra large head felt nails of 3.35 mm shank diameter and 20 mm length made of copper, aluminium alloy or hot-dipped galvanized steel.

2.13.3 Nails for clips

Nails intended for use with clips should be aluminium or stainless steel. Type, shank diameter and length should be determined by the type of clip, batten dimensions and the exposure of the site (see 3.6.3.4.2).

2.13.4 Nails for slates, tiles and shingles

Copper nails intended for use with slates or tiles should conform to the requirements for clout nails specified in BS 1202 : Part 2. For natural slates the minimum shank diameter should be 3.35 mm (see 3.6.3.5.4). For natural slates, tiles and artificial slates the shank diameter and length should be determined by the exposure of the site and the manufacturers' recommendations (see 3.4.1 and 3.6.3.4.2).

Aluminium nails intended for use with slates, tiles or shingles should conform to the requirements for clout slate or tile nails specified in BS 1202 : Part 3. For natural slates the minimum shank diameter should be 3.35 mm (see **3.6.3.5.4**). For natural slates, tiles and artificial slates the shank diameter and length should be determined by the exposure of the site and the manufacturers' recommendations (see **3.4.1** and **3.6.3.4.2**). Nails intended for use with wooden shingles should be of aluminium, hot-dipped galvanized or sherardized steel, phosphor or silicon bronze.

Stainless steel nails should conform to BS 1554 grades 302, 304, 315, 316, 321 or 347. Phosphor or silicon bronze nails should conform to manufacturers' recommendations. Nail sizes should conform to BS 1202 : Part 1.

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

2.13.5 Clips for slates and tiles

2.13.5.1 General

Evidence should be provided that in strength and durability, the clip is fit for the intended use and that the clip, as fitted, does not adversely affect the performance of the tiles or slates on the roof (see annex C).

2.13.5.2 Aluminium alloy

Clips of aluminium alloy should conform to the recommendations given in BS EN 485.

2.13.5.3 Stainless steel

Clips of stainless steel should conform to the recommendations given in BS 1449 : Part 2 and BS 1554 and be of the following specification: steel grade 302, 304, 315, 316, 321 or 347.

2.13.5.4 Other materials

Clips made of other alloy types, non-ferrous metals or polymer based materials which can demonstrate adequate sustained and fatigue strength (see annex C) and durability for the intended conditions of use, may be used.

2.13.6 Hooks and rivets for slates and tiles

It should be demonstrated that the hooks or rivets used are of suitable strength and durability. When fitted, they should not adversely affect the performance of the tiles or slates in the roof.

2.14 Flashings and junctions

2.14.1 General

- The sheet materials used for gutters, flashings, soakers, saddles should conform to the recommendations given in **2.14.2** to **2.14.6**.
- For each application, consideration should be given to the type of metal intended for use in flashings and junctions to ensure that any mechanical or chemical properties do not adversely affect durability of the work.

2.14.2 Lead

Lead sheet should conform to BS 1178. The thickness for the following applications should not be less than:

for valleys	2.24 mm (code no. 5);
for flashings	1.80 mm (code no. 4);
for soakers	1.32 mm (code no. 3);
for saddles	1.80 mm (code no. 4).

NOTE 1. Further advice may be obtained from the Lead Sheet Association.

NOTE 2. An EN for lead sheet is in preparation.

2.14.3 Copper

Copper sheet should conform to the recommendations given in BS 2870. The minimum thickness for the following applications should not be less than:

for gutters (fully supported)	0.45 mm to 0.70 mm (type ½H) depending on gutter width;
for gutters (self supporting):	0.70 mm (type ½H);
for flashings, soakers, saddles:	0.55 mm (type 'fully annealed').

NOTE 1. Further advice may be obtained from the Copper Development Association.

NOTE 2. An EN for copper sheet is in preparation.

2.14.4 Aluminium and aluminium alloy

Aluminium or aluminium alloy should conform to BS EN 485 and BS EN 573. The thickness of aluminium or aluminium alloy for use as gutters, soakers, flashings and saddles should not be less than 0.70 mm. Grades 1199, 1080A, 1050A, 1200 and 3103 are suitable with the temper selected according to the strength and forming properties required.

NOTE 1. Further advice may be obtained from the Aluminium Federation.

NOTE 2. An EN for aluminium sheet is in preparation.

2.14.5 Zinc and zinc alloy

Zinc or zinc alloy should conform to the recommendations given in BS EN 988. The thickness of zinc alloy type for use as gutters, soakers, flashings and saddles should be not less than 0.80 mm.

NOTE 1. Further advice may be obtained from the Zinc Development Association.

NOTE 2. An EN for zinc sheet is in preparation.

2.14.6 Proprietary flashing and junction units

Units which have adequate strength, water resistance and durability and which do not adversely affect the laying and performance of the roofing products, may also be used.

2.15 Mortar

2.15.1 Materials

Materials should conform to the following recommendations.

- | | |
|--------------------------------|--|
| a) Cement | Portland Cement, BS 12 or BS 146. |
| b) Quicklime and hydrated lime | BS 890 or BS 5628 : Part 3. |
| c) Sand | Sand which provides a mortar mix that gives adequate bond strength as described in the requirements given in 3.5.3.4.3 and when tested in accordance with the test method given in annex J. |

NOTE. Most BS 1200 sands are suitable.

- | | |
|---------------|--|
| d) Pigment | BS 1014. |
| e) Admixtures | BS 5075 : Parts 1, 2 and 3 and in accordance with manufacturers' recommendations. |
| f) Water | Water should not contain soluble or suspended matter in quantities which have an adverse effect on the performance of the hardened mortar. |

2.15.2 Mix

The mortar should typically consist of the following mix:

cement and sand: one part cement to three parts sand by volume. Plasticizing admixtures may be added in accordance with the manufacturers' recommendations.

NOTE 1. If the use of other mixes is being considered, attention should be given to the workability of the mix and possible application problems, e.g. the need to avoid unsatisfactory bedding on steep pitches.

NOTE 2. Mortar mixes stronger than the mix described above could lead to excessive shrinkage and lower values of tensile adhesion strength when tested in accordance with the method given in annex J.

2.16 Other fittings and accessories

2.16.1 Hip irons

Hip irons should be formed from steel strip conforming to BS 1449 : Part 1, and be hot-dipped galvanized after cutting, forming and holing. The steel strip should conform to the following dimensions:

- for all roof pitches, hip irons should be 25 mm wide and have a thickness of not less than 5 mm;
- upstands should be of an adequate length to support the hip tile;
- the flat section along the hip rafter should not be less than 400 mm in length and have two holes to enable it to be fastened with at least two 5 mm hot-dipped galvanized screws or nails.

2.16.2 Rooflights

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

There are no British Standards for these products.

NOTE 1. Users should pay particular attention to the durability, light transmission and fire performance of the materials.

NOTE 2. An EN for rooflights is in preparation.

2.16.3 Snow guards and boards

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

There are no British Standards for snow guards and boards.

NOTE 1. Users should pay particular attention to the strength and durability performance of the material to be used.

NOTE 2. Snow guards as fitted should not adversely affect the performance of the roof as laid.

2.16.4 Safety hooks

Safety hooks are proprietary devices which are fixed directly to the roof or building structure and to which safety ropes or harnesses are attached by roofing or maintenance contractors. These devices may be subject to Health and Safety legislation.

NOTE 1. Users should pay particular attention to the strength and durability performance of the material. Safety hooks as fitted should not adversely affect the performance of the roof as laid.

NOTE 2. See also BS EN 517.

2.16.5 Roof walkways

Roof walkways are proprietary devices which are fixed to the roof structure as part of the tile/slate product system. These devices may be required to be present by Health and Safety legislation.

NOTE 1. The roof walkways should not adversely affect the performance of the roof as laid.

NOTE 2. BS EN 516 applies to building elements permanently fixed to pitched roofs, to stand or to walk on during inspection, maintenance or repair operations.



2.16.6 Ventilation products

If proprietary roof space ventilation products are used, they should perform satisfactorily as roofing products and should be:

- a) designed to provide an effective weatherproof air path from the external environment into and/or out of the roof space or roof construction zone;
- b) provide the free air space recommendations given in BS 5250 for the eaves, tile or ridge applications;
- c) prevent access by animals, rodents or large insects.

NOTE. Users should pay particular attention to the resistance to wind load, deluge, driving rain and durability performance of the materials used. Ventilation products as fitted should not adversely affect the performance of the roof.

2.16.7 Dry roofing products

Proprietary dry roofing products and systems may be used to replace mortar to provide a gap-filling and mechanical resistance property at all or some roof details. There are no British Standards for these products.

NOTE. Users should pay particular attention to the resistance to wind load and durability performance of the materials. Dry roofing products as fitted should not adversely affect the performance of the roof.

2.16.8 Rainwater products

Rainwater products should be fitted to the roof at eaves and gullies between roof slopes to drain rainwater and melted snow safely away. Design recommendations for the drainage of roofs and paved areas are given in BS 6367. Rainwater products should conform to the relevant British Standards, e.g. BS 4576 for PVC-U, BS 2871 for copper, BS 416 for cast iron and BS 569 for fibre cement.

NOTE. ENs for roof gutters and downpipes are in preparation.

2.16.9 Lightning conductors

Lightning conductors should be fitted to roofs, particularly of tall buildings in exposed positions or high altitudes to prevent damage by lightning strikes. Lightning conductors may be required by Health and Safety legislation and may be required by law for some metal roofs.

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

NOTE. Lightning conductors should be of a suitable design that they will not adversely affect the performance or aesthetic appearance of the roof, e.g. consider a location beneath the roofing elements.

2.16.10 Eaves filler units

Proprietary eaves filler units are devices fitted at the eaves, primarily of tiled roofs, which possess significant profiles (greater than a 16 mm sphere). These are fitted to prevent access by birds and small rodents. The eaves filler may also provide an air ventilation function.

There is no British Standard for eaves filler units.

NOTE. The eaves filler unit as fitted should not adversely affect the performance of the roof.

Section 3. Design recommendations

3.1 Definitions

3.1.1 deluge rain

High rainfall without wind.

3.1.2 driving rain

Rainfall with wind.

3.1.3 snow

Snowfall with or without wind.

3.2 Rain and snow resistance

3.2.1 General

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

Figure 1 details two categories of exposure based on driving rain penetration data from BS 8104 : 1992 and BRE Report *Thermal insulation: avoiding risks* (second edition 1994) [4]. This map may be used when designing buildings up to 12 m ridge height. For more detailed guidance, reference should be made to BS 8104 : 1992.

3.2.2 Product resistance to rain and snow

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 include: capillary action and rainwater creep; driving rain; deluge rain and flooding; raindrop bounce and negative pressure rain suction, etc.

NOTE. Snow ingress is generally wind driven.

Roofing products may experience one or more of these performance mechanisms which depend 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, macro and micro climate affecting the roof.

The definition of whether a roofing product as laid has a satisfactory rain resistance or snow resistance performance should depend on the building's use, its design life and the roof detailing.

At present, the UK does not have an agreed British Standard performance test or rain or snow resistance test method to assess the pitch and lap performance of pitched roofing products.

The recommendations for rain resistance given are, therefore, prescriptive based on experience.

At present, there are no agreed recommendations for snow resistance.

3.3 Roof pitch, headlaps and sidelaps

3.3.1 Roof pitches

The roof pitches given in tables 2 and 3 are the pitch of the rafter (angle of elevation of the roof structure from the horizontal). The actual pitch of a slate/tile/shingle when laid will be less than the roof pitch.

NOTE. Roof pitches below 75° are included.

3.3.2 Headlaps (double lap)

The headlap 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 3.4.2.1 for tiles and 3.4.4.1 for slates).

NOTE 1. Certain types of shingle are laid to a triple lap.

NOTE 2. Tables 2 and 3 do not apply to single lap products.

3.3.3 Headlaps (single lap)

The headlaps for single lap tiles (see 3.4.3.1) is the distance by which the upper course of tiles provides an overlap with the next course below.

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

3.3.4 Sidelaps (double lap)

For double lap slates/tiles the sidelap is the side distance by which the slate/tile overlaps the slate/tile in the next course below (see figure 2b).

3.3.5 Side laps (single lap)

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

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

3.3.6 Angle of creep (double lap)

See figures 2a and 2b.

The angle of creep can be calculated by using the following equations.

For centre nailed slates:

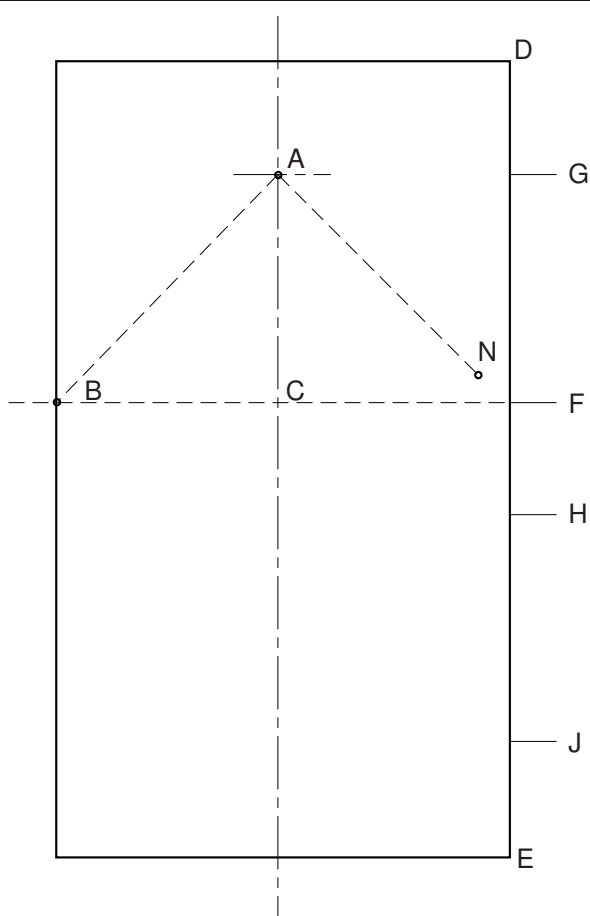
$$CAN = \frac{1}{\tan \phi} \left(\frac{CN}{AC} \right).$$

For head and shoulder nailed or hook fixed slates:

$$CAB = \frac{1}{\tan \phi} \left(\frac{CB}{AC} \right).$$

The maximum angle of creep for a particular slate is the lesser of the following angles: CAN or CAB (see figure 2a).





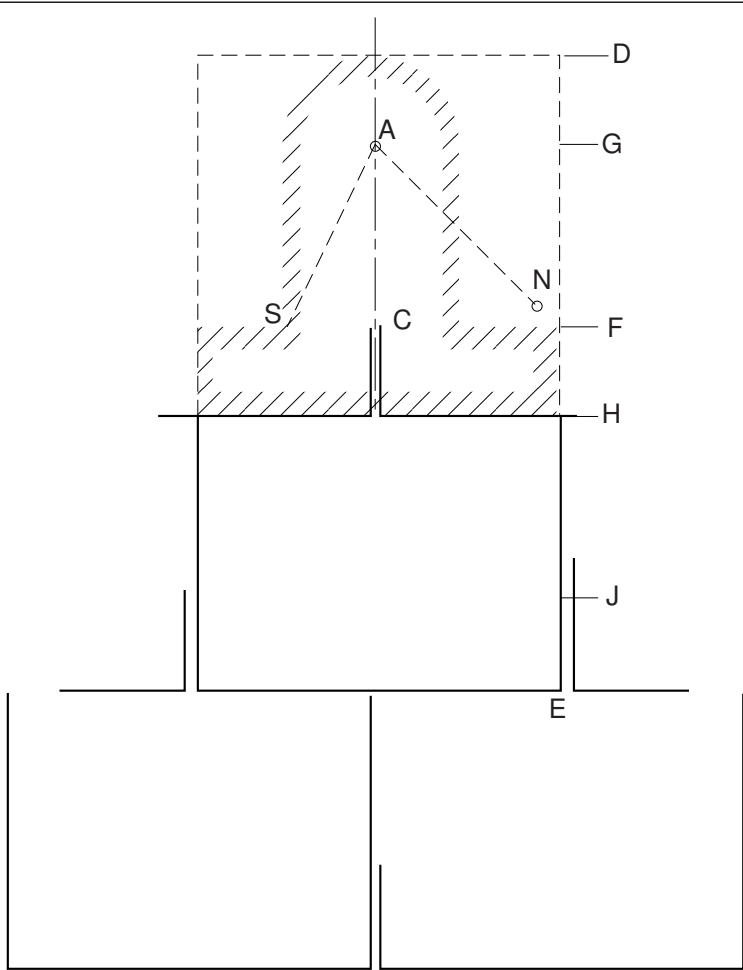
CAN = angle of creep to nail hole

CAB = angle of creep to side edge of slate

NF = horizontal nail hole distance from side edge of slate

a) Angles of creep

Figure 2. Laps and angles of creep for double lap products



NOTE. The shaded area represents the minimum provision of headlap and sidelap and the area of potential creep.

CAN represents the angle of creep of the particular slate.

CAS represents the minimum angle of creep for the conditions of use, given in tables 2 and 3.

Where CAN and CAS are equal, there is no margin for reducing the slate width by cutting during laying.

DG, FH and JE = headlap with the next course but one below.

DE = length of slate

HE = slate margin (and gauge)

EH = HG.

b) Area of side and headlaps

Figure 2. Laps and angles of creep for double lap products
(continued)

If the maximum angle of creep for a particular slate is less than the minimum shown in tables 2 and 3 the sidelap of the slate will be inadequate for the conditions of use.

The minimum width of a slate is given by the following equation:

$$\text{Min. slate width} = \{(DE - 3DG)\tan \phi\} + 2NF$$

For head and shoulder nailed and hook-fixed slates the value of NF is zero.

Table 2. Recommended minimum headlaps and roof pitches and angles of creep for double lap natural, fibre cement and other artificial slates (driving rain exposure < 56.5 l/m² per spell)

Roof pitch (min.) °	Minimum headlap mm	Nominal length of slate			
		560 mm or longer	500 mm	460 mm	Less than 460 mm
		Angle of creep ϕ°			
45	65	26	26	26	26
40	65	26	26	26	26
35	75	26	26	26	29
30	75	32	32	32	32
27.5	85	34	36	39	48
25	90	36	40	47	—
22.5	100	41	47	56	—
20	115	48	56	65	—

NOTE 1. The headlap may be increased in calculating the width of double lap product.

NOTE 2. These recommendations are minimum values which are more critical at roof pitches below 30° (driving rain exposure < 56.5 l/m²) and below 40° (driving rain exposure ≥ 56.5 l/m²). The thickness of the slates will reduce the effective slope of the slate surface.

NOTE 3. For steeper roof pitches it is possible to use a greater angle of creep to allow for a loss of side lap where it is necessary to cut the slates.

NOTE 4. For artificial double lap slating (fibre cement or artificial slates) these recommendations for headlaps and sidelaps apply, except at roof pitches below 25° (driving rain exposure < 56.5 l/m²) and 30° (driving rain exposure ≥ 56.5 l/m²) in which case manufacturers should produce evidence of satisfactory performance (see 3.4.1).

NOTE 5. For triple lap shingles or shakes, refer to manufacturers' technical literature.

NOTE 6. The minimum roof pitch for double lap slating in UK climatic conditions is 20°.

NOTE 7. The calculation of the minimum slate width using the relevant angle of creep is normally based upon a nail hole to side edge distance (NF) of 20 mm to 25 mm. Any greater nail hole to side edge distance will require recalculation of slate width in accordance with the expression given in 3.3.6.

NOTE 8. The headlap should not exceed one third of the length of the slate.

NOTE 9. Hook fixing of slates may require greater headlap than those recommended in tables 2 and 3.

Table 3. Recommended minimum headlaps and roof pitches and minimum angles of creep for double lap natural, fibre cement and other artificial slates (driving rain exposure ≥ 56.5 l/m² per spell)

Roof pitch (min.) °	Minimum headlap mm	Nominal length of slate			
		560 mm or longer	500 mm	460 mm	Less than 460 mm
		Angle of creep ϕ°			
45	65	32	32	32	36
40	75	34	35	40	48
35	75	37	40	45	57
30	75	41	44	50	60
27.5	90	43	47	55	—
25	100	45	50	61	—
22.5	115	52	60	—	—
20	130	60	—	—	—

See notes 1 to 9 of table 2.

3.4 Recommendations for minimum roof pitch, headlaps and sidelaps (roof)

3.4.1 General

When considering the minimum recommendations for pitch and laps for slate and tile products, the specifier should take account of any abnormal conditions which may apply to the proposed use of a generic or proprietary product.

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

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

3.4.2 Double lap clay and concrete plain tiles

3.4.2.1 Headlap

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

NOTE. The design of some products requires a limit to the maximum headlap.

3.4.2.2 Sidelap

Sidelap should not be less than one third of the width of a plain tile. Special and purpose-made hip and valley tiles should provide for sidelaps not less than one third of the width of a plain tile.

3.4.2.3 Roof pitch

Plain tiles should be laid at rafter pitches not less than 35°. Clay tiles which do not meet the dimensional and geometric requirements given in BS 402 should be laid at pitches not less than 40°.

3.4.3 Single-lap clay and concrete tiles (interlocking)

3.4.3.1 Headlap

These products have the headlap fixed by design features on the top surface at the head of the tile and features on the under surface at the tail of the tile. For variable tiles without a head-lock design, the minimum headlap should be not less than 75 mm.

NOTE. The design of some products requires a limit to maximum headlap.

3.4.3.2 Sidelap

The sidelap features are generally of a proprietary side-lock design.

3.4.3.3 Roof pitch

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

3.4.4 Fibre cement slates and natural slates

3.4.4.1 Headlap

A satisfactory headlap should be a function of the length and width of the slate; the exposure category; the roof pitch and the angle of creep. These factors are summarized in tables 2 and 3 and can be used to obtain the recommended headlap for the type of slate and conditions of use.

3.4.4.2 Sidelap

The nature of double lap slating ensures that a notional half width of slate overlaps the slate below. For special circumstances a reduction in sidelap should be assessed in accordance with 3.3.6 and the influence that it has on the angle of creep in relation to the lap and pitch.

3.4.4.3 Roof pitch

The recommended roof pitch for the type of slate and conditions of use can be obtained from tables 2 and 3. The minimum roof pitch should be 20°.

Where abnormal conditions are expected, for example on elevated sites, near to the coast, or where high snow or rainfalls are experienced, table 3 can be used to obtain the recommended headlap and roof pitch. Table 2 can be used for other situations.

3.4.5 Bitumen shingles

3.4.5.1 General

Bitumen shingles, which are proprietary products of variable design, may be laid and fixed with or without an adhesive section in the headlap area.

3.4.5.2 Overlap

The overlap for bitumen shingles should be not less than 200 mm.

3.4.5.3 Sidelap

The sidelap for bitumen shingles should be not less than half the width of the tab width.

3.4.5.4 Roof pitch

The roof pitch for bitumen shingles should be as recommended by the manufacturer based on evidence in use (see 3.4.1).

3.4.6 Wooden shingles and shakes

3.4.6.1 General

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

3.4.6.2 Headlap

The headlap for wooden shingles and shakes should be a function of the length and thickness of the shingle or shake, the exposure category, the roof pitch and the surface characteristics of the product.

3.4.6.3 Sidelap

The sidelap for wooden shingles and shakes should be not less than 38 mm.

3.4.6.4 Roof pitch

Roof pitches may be recommended by the manufacturer based on evidence in use (see 3.4.1).

3.4.7 Metal tiles

3.4.7.1 General

Metal tiles, which are proprietary products of variable design, may be laid and fixed to different specifications.

3.4.7.2 Headlap

Metal tiles have the headlap fixed by the design features of the head and tail.

3.4.7.3 Sidelap

The sidelap for metal products is fixed by the design features which are typically related to the centres of the corrugation and shaped features.

3.4.7.4 Roof pitch

The roof pitch for metal tiles should be in accordance with manufacturers' recommendations based on relevant experience in use or relevant test data reflecting appropriate climatic conditions.

3.4.8 Other tiles and slates

Manufacturers of other proprietary tiles and slates which include composite, resin filled or bonded and lightweight products, etc., of variable design, should produce evidence of satisfactory prolonged and extensive use of their products at the roof pitches, headlaps and sidelaps for which they are intended to be used. For example; evidence that products have been shown to be satisfactory for not less than 15 years in the location of intended use; or evidence from an appropriate test method which may be directly correlated with the recommended conditions of use.

3.4.9 Application of roof products below recommended roof pitch, headlap or sidelap

3.4.9.1 There are design situations where it would be difficult to avoid using a roofing product, fitting or accessory below the recommended roof pitch, headlap or sidelap. These situations may include, for example, a lean-to on an existing building where a window, cavity tray line or boundary restricts the roof pitch. In these situations, it is to be expected that the roof covering may experience rain or snow penetration.

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

3.4.9.2 It is recommended that a roof designed below the recommended roof pitch should have a functional underlay sub-roof system to remove any rainwater ingress safely to the eaves gutter. Proprietary roofing underlays may also be used. However, it should have adequate strength, water resistance, nail tear resistance, water vapour resistance (where required) and durability. The underlay should not adversely affect the laying and performance of roofing products.

NOTE. Users should also refer to British Board of Agrément Certificates and manufacturers' technical data which are relevant to UK conditions of use and to NFRC Technical Bulletin No. 6 [2].

3.5 Recommendations for minimum headlaps, sidelaps and overlaps for vertical walls (75° and above)

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

3.5.1.1 Headlap

Headlaps for double lapped clay and concrete plain tiles should be not less than 37.5 mm. Headlaps for double lapped slating should be not less than 44.5 mm.

3.5.1.2 Sidelap

Sidelaps for double lapped clay and concrete plain tiles, fibre cement slates and natural slates should be in accordance with 3.4.2.2 and 3.4.4.2.

3.5.2 Single lap clay and concrete tiles (interlocking)

3.5.2.1 Headlap

These products may have the headlap fixed by design features on the top surface at the head of the tile and/or features on the under surface at the tail of the tile. For variable headlap products the headlap should be not less than 35 mm below the nail hole.

3.5.2.2 Sidelap

The sidelap features are generally of a proprietary side-lock design.

3.5.3 Bitumen shingles

3.5.3.1 Overlap

For bitumen shingles the overlap should be not less than 200 mm.

3.5.3.2 Sidelap

For bitumen shingles the sidelap should be not less than half the width of the tab.

3.5.4 Wooden shingles and shakes

3.5.4.1 Headlap

A satisfactory headlap for wooden shingles and shakes should be a function of the length and thickness of the shingle or shake, the exposure category, the roof pitch and surface characteristics of the product.

3.5.4.2 Sidelap

The sidelap for wooden shingles and shakes should be not less than 38 mm.

3.5.5 Metal tiles

3.5.5.1 Headlap

The headlap for metal tile products is fixed by the design features of the head and tail of the metal tile.

3.5.5.2 Sidelap

The sidelap for metal tile products is fixed by design features which are typically related to the centres of the corrugation and shaped features.

3.5.6 Other tiles and slates

Manufacturers of other proprietary tiles and slates which include composite, resin filled or bonded and lightweight products etc., should produce evidence of the satisfactory prolonged and extensive use of their products at the roof pitches, headlaps and sidelaps for which they are intended to be used. For example; evidence that products have been shown to be satisfactory for not less than 15 years in the location of use; or evidence from an appropriate test method which may be directly correlated with the recommended conditions of use.

3.6 Structural stability

3.6.1 Dead and imposed loads

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

3.6.2 Wind loads

3.6.2.1 General

The effective wind speed V_e and the dynamic pressure of the wind q_s appropriate to the location, altitude and other topographical conditions in the United Kingdom should be calculated in accordance with the standard method described in BS 6399 : Part 2, taking the size effect factor, C_a , as 1.0 for slating/tiling. The appropriate pressure difference coefficient C_{pt} depends on the roof geometry and building and should be obtained from table 7. Alternatively, for more complex roof shapes, appropriate C_{pe} values may be obtained from the more precise data given in BS 6399 : Part 2 and these should be used in conjunction with values for uplift pressure reduction factor, R , from annex B.

The wind uplift load on discontinuously laid small element roofing products with unsealed laps should be derived taking into account air permeability through the side and endlaps according to the equations given in 3.6.2.1 to 3.6.2.4.

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

3.6.2.2 Wind loads on small roof covering elements with unsealed laps (excluding ridges, hips and valleys)

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

a) For roof coverings that do not overhang either the verge or eaves by more than 50 mm:

use equation (1):

$$F_t = q_s \times C_{pt} \times A_t \times D \times S \quad (1)$$

where

$$A_t = B \times G_a;$$

F_t is the wind uplift load (in N);

q_s is the dynamic pressure of the wind (in N/m²), calculated from the equation $q_s = 0.613V_e^2$, where V_e is in m/s and is derived from BS 6399 : Part 2;

A_t is the exposed area of the roofing element (in m²);

D is the air permeability factor given by the equation $D = (\log_{10}K) - 1$, appropriate values being given in table 8 or obtained by test in accordance with annex A;

S is a roof substrate shielding factor, appropriate values being given in table 9;

C_{pt} is the pressure difference coefficient.

b) For roof coverings that overhang the eaves by more than 50 mm:

there are two loads acting simultaneously, $F_{o,e}$ and $F_{t,e}$. $F_{o,e}$ acts on the overhanging part and is given by equation 2, and $F_{t,e}$ acts on the part protected by the underlay and is given by equation 3.

$$F_{o,e} = q_s \times \{(C_{pt}/R) - 0.8\} \times A_{o,e} \quad (2)$$

where

$$A_{o,e} = B (L_0 - 0.05).$$

$$F_{t,e} = q_s \times C_{pt} \times A_{t,e} \times D \times S \quad (3)$$

where

$$A_{t,e} = B(G_a - L_0 + 0.05).$$

The total load on the tile should be calculated from the sum of the overturning moments from the forces $F_{o,e}$ and $F_{t,e}$.

c) For roof coverings that overhang the verges by more than 50 mm:

There are two loads acting simultaneously, $F_{o,v}$ and $F_{t,v}$. $F_{o,v}$ acts on the overhanging part and is given by equation 4, and $F_{t,v}$ acts on the part protected by the underlay and is given by equation 5.

$$F_{o,v} = q_s \times \{(C_{pt}/R) - 0.8\} \times A_{o,v} \quad (4)$$

where

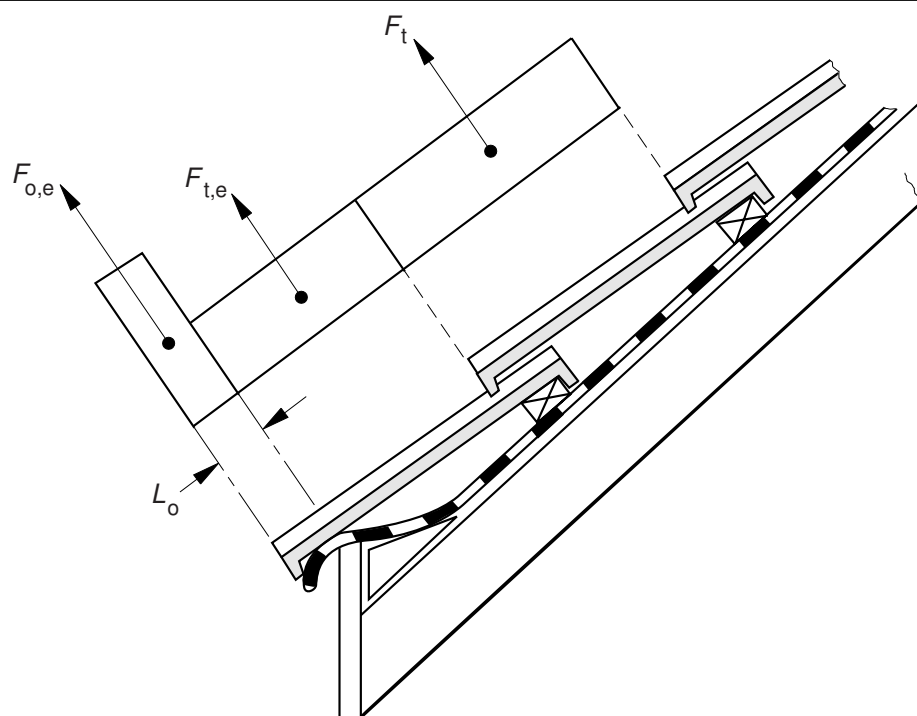
$$A_{o,v} = G_a (B_0 - 0.05) \text{ (see figure 3).}$$

$$F_{t,v} = q_s \times C_{pt} \times A_{t,v} \times D \times S \quad (5)$$

where

$$A_{t,v} = G_a (B - B_0 + 0.05) \text{ (see figure 5).}$$

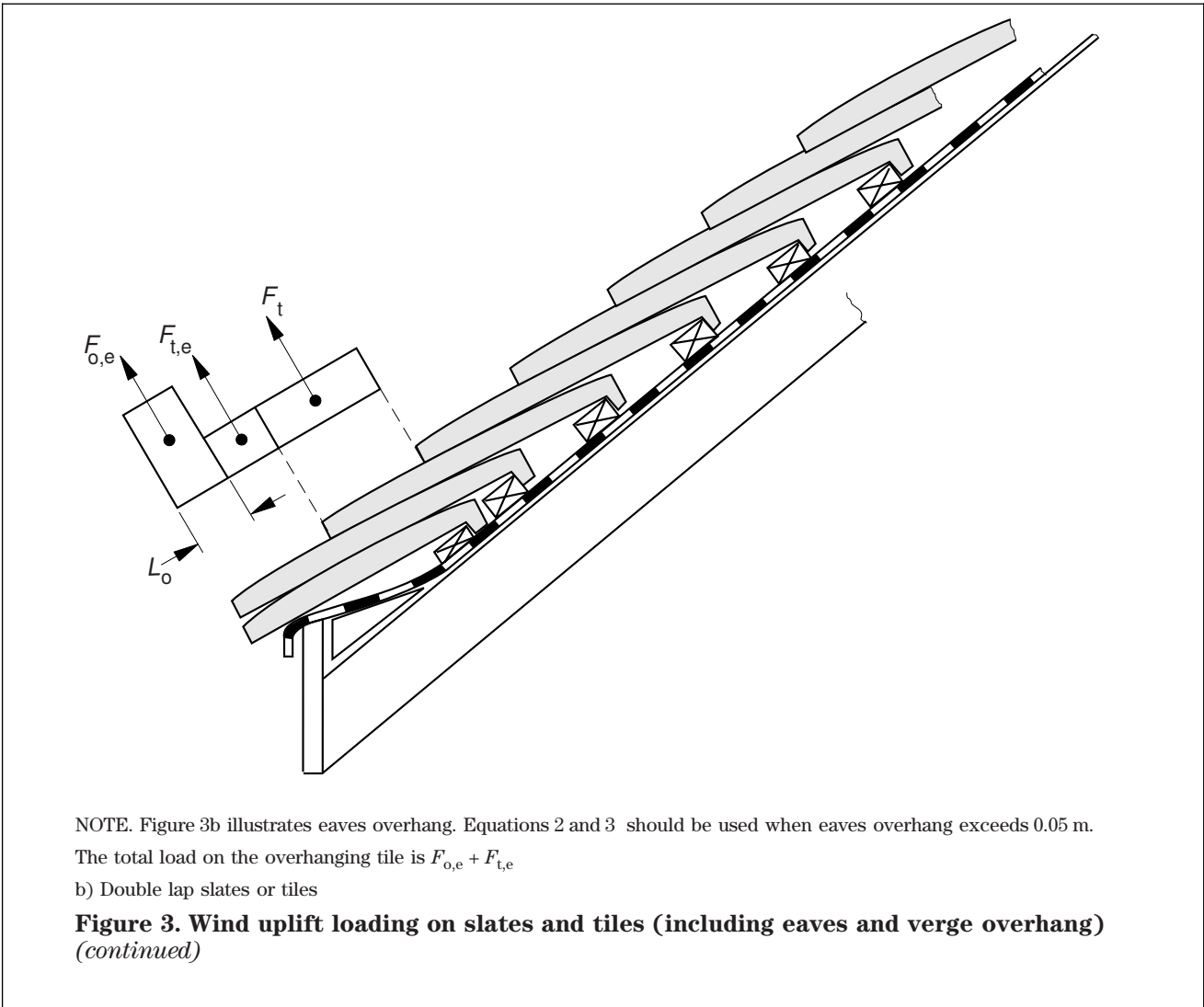
The total load on the tile should be calculated from the sum of the overturning moments from the forces $F_{o,v}$ and $F_{t,v}$.

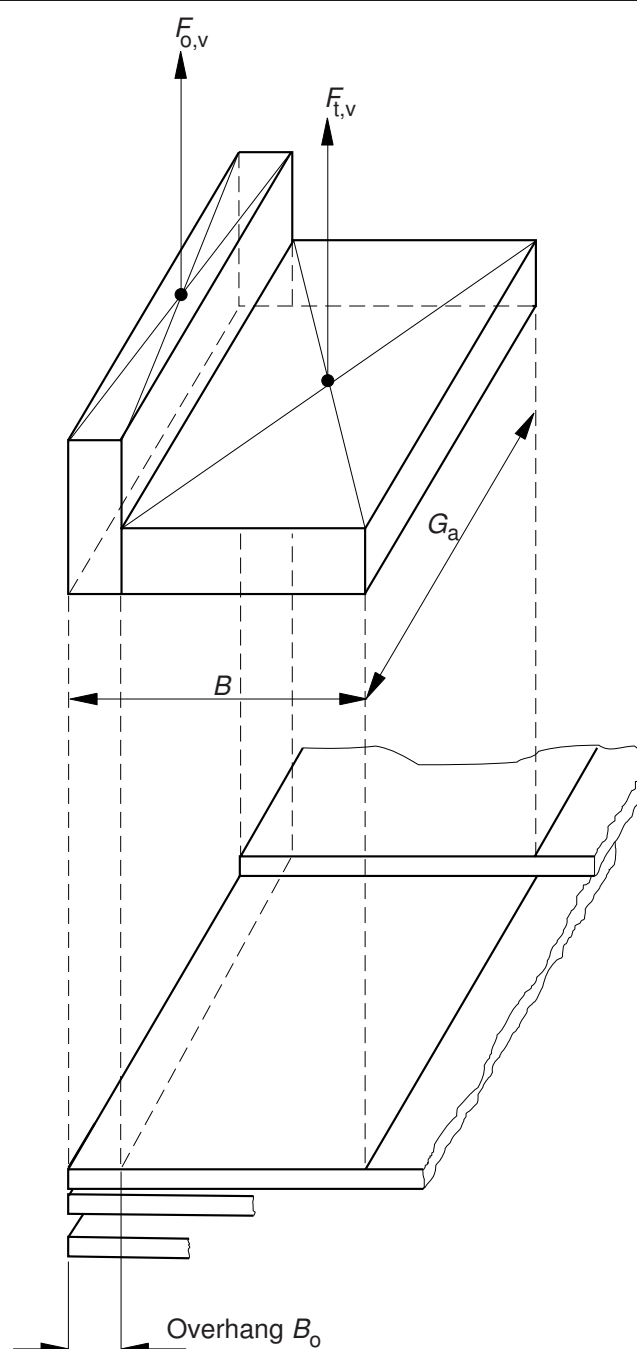


NOTE. Figure 3a illustrates eaves overhang. Equations 2 and 3 should be used when eaves overhang exceeds 0.05 m.

a) Single lap tiles

Figure 3. Wind uplift loading on slates and tiles (including eaves and verge overhang)





NOTE. Figure 3c illustrates verge overhang. Equations 4 and 5 should be used when the verge overhang exceeds 0.05 m.

The total load on the overhanging tile is $F_{o,v} + F_{t,v}$

c) Single lap tiles

Figure 3. Wind uplift loading on slates and tiles (including eaves and verge overhang)
(continued)

