

Code of practice for

The use of profiled sheet for roof and wall cladding on buildings —

Part 1: Design

ICS 91.100

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

BSI
Documents

AVA

Document Sharing Hub

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/542/6, Corrugated sheeting materials, upon which the following bodies were represented:

- Aluminium Federation
- Association of Building Component Manufacturers
- Association of Rooflight Manufacturers
- British Iron and Steel Producers' Association
- British Plastics Federation
- Cold Rolled Sections Association
- Department of the Environment (Building Research Establishment)
- Fibre Cement Manufacturers' Association
- Flat Roofing Contractors Advisory Board
- Institution of Structural Engineers
- Metal Cladding and Roofing Manufacturers' Association
- Metal Roof Deck Association
- National Association of Steel Stockholders
- National Federation of Roofing Contractors
- Royal Institute of British Architects
- Steel Construction Institute

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 July 1996

© BSI 02-1999

The following BSI references relate to the work on this standard:
Committee reference B/542/6
Draft for comment 89/11231 DC

ISBN 0 580 25738 X

Amendments issued since publication

Amd. No.	Date	Comments

Contents

	Page
Committees responsible	Inside front cover
Foreword	iii
Section 1. General	
1.1 Scope	1
1.2 References	1
1.3 Definitions	1
Section 2. Materials and components	
2.1 Profiled sheeting	4
2.2 Surface coatings for profiled sheeting	4
2.3 Accessories	5
2.4 Thermal insulation materials	5
2.5 Condensation control materials	5
2.6 Liners	5
2.7 Sealants	6
2.8 Fasteners	6
2.9 Rooflights	9
2.10 Rainwater goods	10
Section 3. Design	
3.1 General considerations	11
3.2 Weathertightness	11
3.3 Appearance	15
3.4 Structure	15
3.5 Fixings	18
3.6 Thermal insulation	21
3.7 Control of condensation	22
3.8 Temperature and thermal movement	25
3.9 Compatibility of materials	28
3.10 Fire precautions	28
3.11 Sound insulation	30
3.12 Lighting	32
3.13 External attachments	32
3.14 Guttering	32
3.15 Protection against lightning and induced electrical charges	33
3.16 Design detailing	33
3.17 Durability and maintenance	36
Annex A (normative) Determination of strength and stiffness of profiled sheeting, including sandwich panels	39
Annex B (normative) Determination of the strength of attachment of a cladding system	41
Annex C (normative) Durability of natural, inorganic and metallic finishes	43
Annex D (normative) Durability of organic finishes on steel and aluminium	45
Annex E (informative) Text of BS 476 "Fire tests on building materials and structures" Part 3:1958 "External fire exposure roof tests"	49
Appendix A	52
Appendix B	52
Figure 1 — Geometrical definitions of profiles	3
Figure 2 — Examples of fasteners	8

	Page
Figure 3 — Minimum fall required to avoid ponding by sheeting deflection	12
Figure 4 — Supported roof side lap	13
Figure 5 — Side laps for wall cladding	13
Figure 6 — Examples of spacer systems	20
Figure 7 — Illustrations of warm, cold and hybrid insulation	23
Figure B.1 — Examples of test rigs for determination of strength of fixings	42
Figure 1 — Roof test apparatus	51
Table 1 — British Standards for profiled sheeting materials and their use	4
Table 2 — Common insulating materials	5
Table 3 — Standards for rainwater goods	10
Table 4 — Normal maximum permissible deflection for profiled sheeting under distributed loads	16
Table 5 — Accommodation of thermal movement along sheets	26
Table 6 — Temperature limitations	27
Table 7 — Typical fire classification	31
Table 8 — The effect of various exposure conditions on the durability of profiled sheeting materials	34
Table 9 — Checklist for inspection of roofs	38
Table C.1 — General characteristics	43
Table C.2 — Functional life of profiled materials	44
Table D.1 — Organic coatings on aluminium	45
Table D.2 — Organic coatings on primed zinc-coated steel	46
Table D.3 — Organic coatings on aluminium	47
Table D.4 — Organic coatings on hot-dip zinc coated steel	48
Table D.5 — Performance of PVC plastisol	48
List of references	54

Foreword

This Part of BS 5427 has been prepared by Technical Committee B/542. It is a revision of BS 5427:1976, which is withdrawn.

This edition takes into account recent changes and developments in materials, components, cladding systems and design practice, such as sheeting profiles, surface coatings, fixing systems, thermal insulation, the use of liners, and alleviation of condensation.

Further Parts of this standard covering the installation of profiled metal and fibre cement sheeting are to be prepared. These will replace the following existing Standards, which will be withdrawn in due course:

BS CP 143-1;

BS CP 143-10; and

BS 5247-14.

It has been assumed in writing this standard that the design of external cladding is entrusted to suitably qualified designers and that construction is carried out by competent operatives and supervisors.

Five annexes are included. Annex A details a method for the determination of strength and stiffness of profiled sheeting, including sandwich panels, Annex B details a method for the determination of the strength of attachment of a cladding system, Annex C and Annex D give guidance on the durability of finishes and Annex E reproduces the text of BS 476-3:1958, which has been withdrawn but which, nevertheless, is still referenced in the Building Regulations.

As a code of practice, this Part of BS 5427 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.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 56, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1.1 Scope

This code of practice gives recommendations for the design and construction of external cladding assemblies for roof and walls of buildings in the UK, using profiled sheeting as the external surface. It does not deal with profiled sheeting used as a supporting substrate (decking) to form elements such as built-up roofing, structurally composite formations of profiled metal sheeting and concrete, small element cladding such as simulated slating and tiling, nor exceptional applications such as buildings for cold storage.

The principal profiled sheeting materials considered in this British Standard are steel, aluminium, fibre cement and plastics, including composite assemblies of profiled sheeting, thermal insulation and linings.

In addition to referencing performance requirements, materials and components identified by British Standards, advice on other materials and components which are in common use but not covered by British Standards is also given.

NOTE For materials and components not so covered, evidence of their satisfactory performance and suitability for use in particular conditions should be obtained and carefully assessed. For certain proprietary materials and components, guidance may be available from Agrément Certificates or European Technical Approvals.

Attention is drawn to statutory requirements.

1.2 References

1.2.1 Normative references

This Part of BS 5427 incorporates, by dated or undated reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on page 53. Subsequent amendments to, or revisions of, any of these publications apply to this part of BS 5427 only when incorporated in it by updating 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 5427 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 the inside back cover, but reference should be made to the latest editions.

1.3 Definitions

For the purposes of this Part of BS 5427, the definitions of roof and wall cladding terms given in 1.3.2 of BS 6100 apply, together with the following.

NOTE Geometrical definitions of profiles are illustrated in Figure 1.

1.3.1

cladding assembly

roof or wall covering system, which may be a site assembly of liner, spacer and profiled sheeting elements together with insulation and vapour control layers, a composite panel or a bonded panel

1.3.2

profiled sheeting

sheeting, longitudinally formed with regularly spaced shapes of corrugated or trapezoidal cross sections, including substantially flat sheeting with side lapping profiles, which can support load over a span

1.3.3

composite panel (or sandwich panel)

panel that consists of two parallel profiled sheets separated by and factory-filled with insulation adhering to the profiled sheets, the assembly designed to act as a composite structural element

1.3.4

bonded panel

panel that consists of a profiled sheeting bonded by gluing to insulating board

1.3.5

fixing

system of connection between two or more profiled sheets or between profiled sheets or accessories and supporting structure

1.3.6

primary fixing

fixing that secures profiled sheeting or lining to the supporting structure (sheeting to purlin or spacer, spacer to purlin)

1.3.7

secondary fixing

fixing that secures the laps of profile sheets to each other but not to the supporting structure; and used to attach accessories

1.3.8

rigid fixings

fasteners that rigidly connect materials together, typified by self-drilling and self-tapping screws where any movement is accommodated by the connecting materials themselves, i.e. roof sheet and/or spacer or structure. No allowance for movement is required in the connection itself

1.3.9

non-rigid fixings

fasteners that, by the nature of their design, can permit thermal or other movement to take place between the connecting materials. Typical fasteners are hook bolts and bolts with elastomeric sleeves. Self-drilling and self-tapping screws can also be used where clearance holes or slots in the sheeting, together with purpose designed washers, allow movement

1.3.10

fastener

connecting device for the fixing

1.3.11

fibre cement

cement reinforced with asbestos, natural or man-made fibres

NOTE Where significant differences are evident between the different fibres used to reinforce the cement matrix, these are detailed in this Part of BS 5427.

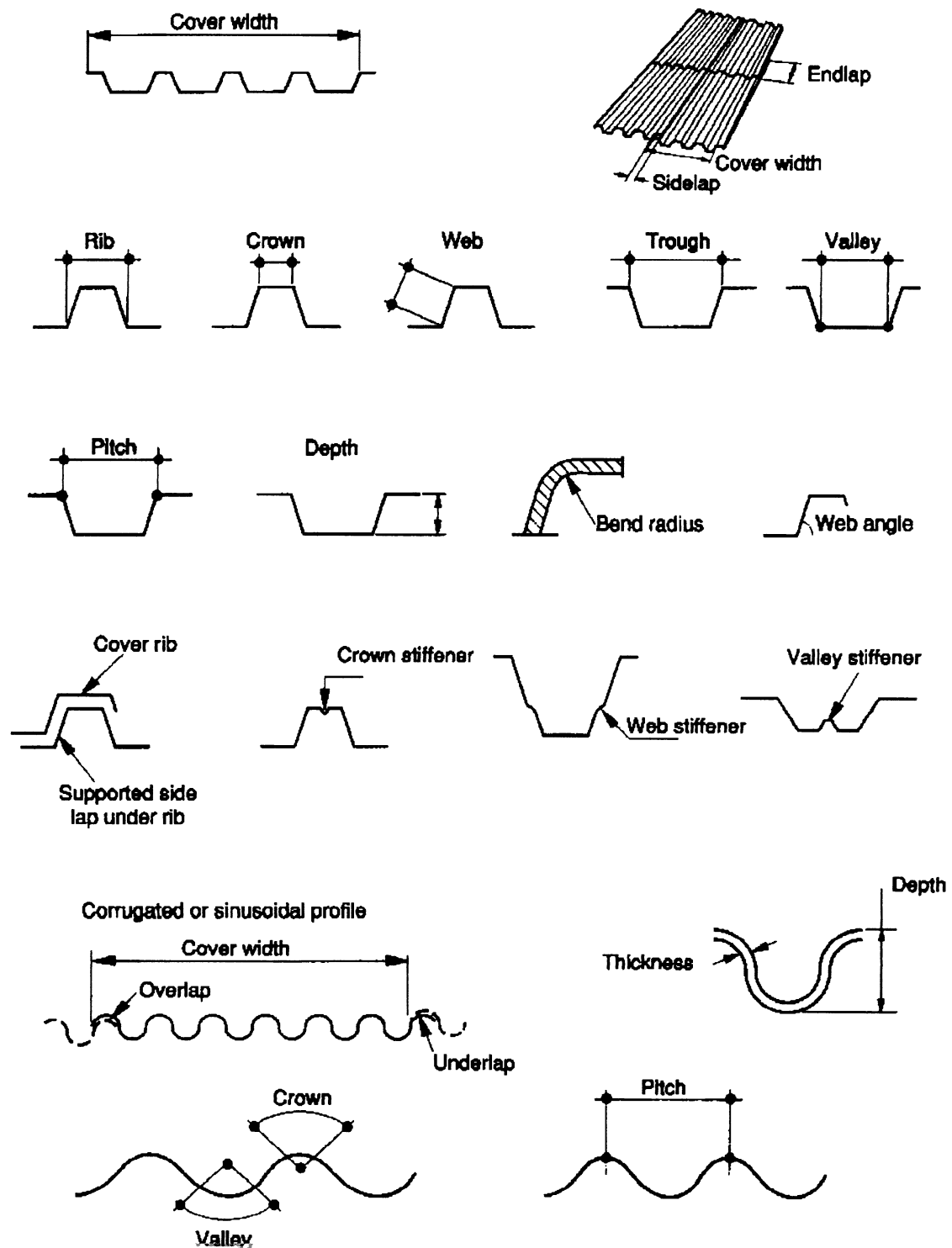


Figure 1 — Geometrical definitions of profiles

Section 2. Materials and components

2.1 Profiled sheeting

Profiled sheeting is available in coated steel, stainless steel, aluminium, fibre cement, and various plastics. The profiled sheeting and the materials from which it is made, and its use, should conform to the relevant British Standards listed in Table 1.

In addition to the profiles covered by the Standards in Table 1 there are many other proprietary profiles and sheeting systems in common use, including standing seam or concealed-fixed cladding systems with wide troughs and narrow upstands for snap-on or sprung-fixed side lapping.

The maximum length of profiled sheeting available depends on the method of manufacture and the convenience of handling, transport and erection. Long lengths laid continuously over several supports reduce the number of end laps and risk of rain penetration.

2.2 Surface coatings for profiled sheeting

Metal profiled sheeting is usually protected with an organic coating applied before profiling, on one or both faces to the same or different specification, so as to provide additional durability and/or choice of colour. Organic coatings of paint or plastics on steel sheeting should be applied to hot dip zinc coated or Al/Zn alloy coated steel. Aluminium and fibre cement sheeting do not require coating for primary surface protection and may be used in their natural state. In some environments hot dip zinc and 55 % aluminium/zinc alloy coatings of the appropriate thickness may also provide adequate durability without additional organic coating.

The durability of a particular plastics coating or paint of given thickness may be significantly affected by its surface colour. Light colours reflect thermal radiation more efficiently, resulting in lower surface temperatures in summer and higher surface temperatures in winter, which reduce degradation of the coating and extend its durability.

A guide to the durability of coatings is given in Annex D.

Table 1 — British Standards for profiled sheeting materials and their use

Material		Specification	Code of practice
Steel:	Hot dip zinc coated sheet	BS EN 10143, BS EN 10147	—
	Hot dip Al/Zn coated sheet	BS EN 10215	—
	Hot dip zinc coated corrugated profiles	BS 3083	—
	Organic coated steel sheet	BS 6781	—
	Profiled steel sheeting	BS 5950-7	BS 5950-6 BS 5950-9
Aluminium:	Alloy sheet	BS EN 485-1	BS 8118-1
		BS EN 485-3	
		BS EN 485-4	—
		BS 8118-2	—
	Profiled sheeting	BS 4868	—
Stainless steel: Sheet		BS 1449-2	—
Fibre cement		BS EN 494	BS 5247-14
Bitumen fibre		—	—
Glass reinforced plastics:		BS 4154-1	—
Corrugated translucent sheeting		BS 4154-2	—
Extruded rigid PVC sheeting		BS 4203-1	—
		BS 4203-2	—
Polycarbonate		—	—

The following physical properties of coatings should be considered:

- a) colour fastness;
- b) dry film thickness;
- c) scratch resistance;
- d) abrasion resistance;
- e) adhesion;
- f) impact resistance;
- g) bend resistance;
- h) corrosion resistance;
- i) extreme temperature resistance;
- j) weathering resistance;
- k) salt spray resistance;
- l) fire performance.

NOTE Most of these properties can be measured by methods of test given in the appropriate Parts of BS 3900. Guidance cannot be given on the acceptable levels of performance of these properties in different exposure conditions. However, such test results can provide a basis of comparison between different coatings and substrate.

2.3 Accessories

Accessories such as barge boards, finials or ridge ends, ridge and hip cappings, flashings and soakers, filler or closure pieces are an essential part of the sheeting system. They are generally available in materials and profiles matching or compatible with the sheeting. Care should be taken to avoid bimetallic corrosion between certain dissimilar metals in contact with each other (see 3.9).

2.4 Thermal insulation materials

Thermal insulation materials should conform to the appropriate British Standards listed in Table 2.

Table 2 — Common insulating materials

Material	British Standard
Expanded polystyrene board	BS 3837-1
Rigid polyurethane and polyisocyanurate foams	BS 4841-2
Resin bonded mineral fibre slabs	BS 5803-1
Glass and other mineral fibre mats	No BS
Phenolics	BS 3927

2.5 Condensation control materials

2.5.1 Vapour control materials

A vapour control layer may consist of one or more sheets such as plastics, bituminous felt, and aluminium foil. The most commonly used materials have a vapour resistance in excess of 200 MNs/g, but their effective resistance will be reduced by imperfect joints or accidental perforation.

Vapour control layers should be durable against water vapour and resistant to perforation. Where the cladding layers are air-permeable, the vapour control layer and its fixings should be resistant to wind pressure.

NOTE Suitable liners installed with sealed joints can act as a vapour control layer.

2.5.2 Vapour resistance

Vapour leakage through unsealed joints or perforations reduces significantly the effective vapour resistance of vapour control layers and should be taken into account, as recommended in BS 6229.

NOTE Vapour resistance values may be determined by the methods of test given in BS 3177 for flexible sheet materials, and BS 4370-2 for cellular materials.

2.6 Liners

2.6.1 General

Liners of various materials, including metals, fibre cement and rigid boards of plasterboard and insulation material may be used to form the internal surfaces of roof and wall cladding assemblies. These are available, often with pre-decorated surfaces, as proprietary systems including fixing and supporting accessories.

The structural stability of the liner system as a whole should be considered. Liners of any type should have adequate strength and stiffness to support their own self weight, the dead weight of insulation, vapour control layer and other attachments.

Liners should be able to resist internal pressures in both directions induced by wind acting on the building under the most likely conditions of unfavourable dominant openings. Where liners are required to provide temporary cover to the building during construction before the cladding installation is completed, they should be able to resist wind loads of the appropriate return period as given in BS 6399-2, and any other construction loads.

Where fixtures are required on the lining system, reinforcing may be required. Where impact resistance is required, reference should be made to BS 8200.

NOTE See also *Partitions: Technical guidance and performance specifications*, MOB 08.101, published by the Property Services Agency.

The fire properties of the lining material and its facing should be considered in relation to its application.

2.6.2 Metal liners

Metal liners are available in the form of pre-coated profiled sheets of steel or aluminium, or in the form of liner trays that incorporate an integral spacer or structural element.

NOTE Metal liners are usually used in conjunction with rigid foam or mineral fibre insulation. When used with sealed joints, metal liners can act as a vapour control layer.

Adequately fixed profiled metal liners can provide lateral restraint to the supporting purlins, but confirmation should be sought from the designer (see 3.4.6). Perforated metal liners can be used to reduce the volume of internally reflected sound. Such liners should not be assumed to provide lateral restraint to purlins, nor can they provide a vapour control layer without an additional membrane.

2.6.3 Rigid board liners

2.6.3.1 General

Rigid board liners are available in plasterboard or panels of rigid insulation material of various types.

NOTE Guidance on the selection and application of plasterboard linings is given in BS 8212.

Where plasterboard linings incorporate laminates of vapour check material, reflective metal foil and surface finishes, they should not be relied upon to modify the moisture sensitivity of the base material.

For roofs and walls where high humidity conditions are likely to prevail for long periods, e.g. in laundries and swimming pools, or where the temperature of the board surface is likely to rise above 50 °C, rigid board liners should not be used. Where board liners are to be exposed for short periods to humidity or moisture, e.g. in kitchens and bathrooms, moisture resistant boards should be used. Plasterboard liners should not be used for roofs where the building may be left intermittently unheated.

NOTE The facings on panels of rigid insulation material and the panels themselves usually have an adequate vapour resistance for the typical low humidity industrial building.

Where fibre cement weathering sheets are used over rigid insulation material, there should be a dense load distribution strip over each purlin position to avoid local compression of the insulant. The manufacturers of the lining system and the fibre cement sheeting should be consulted about a suitable distribution strip material.

2.6.3.2 Edge support and jointing

Where edge support for board type liners is required the manufacturer's advice should be sought. Liner systems based on panels of gypsum plasterboard or rigid insulation materials are available with galvanized T-bar supports and fixing straps.

The joints between the board and supporting T-bars, and gaps that occur where the lining is penetrated, e.g. at rooflights or ventilators, require attention to prevent humid air entering the roof cavity from inside the building. Advice on the need to seal the joints and gaps described above and the recommended method of achieving a vapour check should be sought from the board manufacturers.

2.7 Sealants

Sealants, where used, should provide a watertight barrier at end and side laps and at the joints between profiled sheeting and its accessories. Consideration should be given to the durability of the sealant, taking into account the design life of the cladding system and the importance of the sealant within it. Where sealants are used, they should have the following properties:

- a) non-setting;
- b) non corrosive to the joined components;
- c) gap filling;
- d) retain elasticity within the design temperature range over the predicted life;
- e) suitable compressibility under load;
- f) adhesion;
- g) sliding and rolling properties for movement joints;
- h) water resistance;
- i) chemical compatibility with the sheet or coating;
- j) U.V. resistance where exposed to ultra violet light.

NOTE BS 6093 gives recommendations for the design of joints and jointing in building construction.

2.8 Fasteners

2.8.1 General

BS 1494-1 specifies requirements for the following fasteners and accessories of steel and aluminium for sheet, roof and wall coverings:

- a) hook bolts and nuts;
- b) drive screws;
- c) washers (steel, aluminium and plastics);
- d) self-tapping screws;
- e) roofing bolts, nuts and clips;
- f) roofing screws;

g) sheeting clips.

Proprietary fasteners have been developed, particularly self drilling screws, rivets, washers and colour heads, to meet the fixing requirements of multi-layer cladding systems incorporating thermal insulation, condensation control layers and internal linings. Fastener and cladding manufacturers should be consulted on the choice of fasteners for the cladding design and the suitability of fasteners should be evaluated from examining the performance data available.

NOTE 1 Examples of fasteners are illustrated in Figure 2. Annex A gives methods for determining the strength of fasteners and fixings.

The protective coating of fasteners should be of adequate resistance to corrosion comparable to that of the sheeting, in the intended environment of use.

NOTE 2 At present there are no British Standards for evaluating the corrosion resistance of fasteners. However, German Standard DIN 50018, specifying a method of test on the appearance of rust after exposure to an alternating atmosphere containing sulfur dioxide, is often used for this purpose.

2.8.2 Fixings

2.8.2.1 Primary fixings

Primary fixings should have adequate strength to resist the design dead, imposed and wind loads and maintain weathertightness and, where required by the cladding and support design, provide adequate lateral restraint to substructure elements such as purlins and spacers. In addition, they may be required to accommodate some thermal movement in the direction of the profiles (and transversely in the case of inflexible sheets). This can be achieved by oversize fixing holes or by elastic displacement of purlins and spacers. Primary fixings are divided into two types:

- a) rigid fixings (see 1.3.8);
- b) non-rigid fixings (see 1.3.9).

It is essential that the watertightness of fixings with fasteners penetrating the sheeting should remain effective when the sheeting is subjected to the maximum inward imposed and wind loads. Under such loads, the sheeting and any insulating substrate would compress and thereby tend to loosen the seal in the fastener, increasing the risk of water penetration. It is therefore important to ensure that the sheeting, substrate and fastener, including sealing washer, can provide adequate performance under these conditions. Additional security can be obtained by the use of fasteners which secure the sheeting against inward movement as well as against outward loads (see 2.8.5).

2.8.2.2 Secondary fixings

The primary function of secondary fixings is to maintain a tight lap and seal, but they are also required to transfer concentrated load to adjacent sheets.

2.8.3 Materials for fasteners

Fasteners should be of materials with adequate strength to resist without failure or excessive deformation the loads imposed on them and the connected elements during installation and service.

Self tapping screws and self drilling screws should have adequate hardness to cut threads and, in the case of self drilling screws, drill through the material and thicknesses of the profiled sheeting and structural element to be connected, but without stripping the threads in the fasteners or connected element when correctly installed.

Carbon steel fasteners should be provided with a protective coating of electroplated zinc or cadmium, sherardizing or hot dip zinc of adequate thickness (see BS 1494-1). This may be supplemented by a coating of hard, durable plastics material. Fasteners are also available in aluminium and stainless steel. Care should be taken to avoid conditions of bimetallic corrosion (see 3.9).

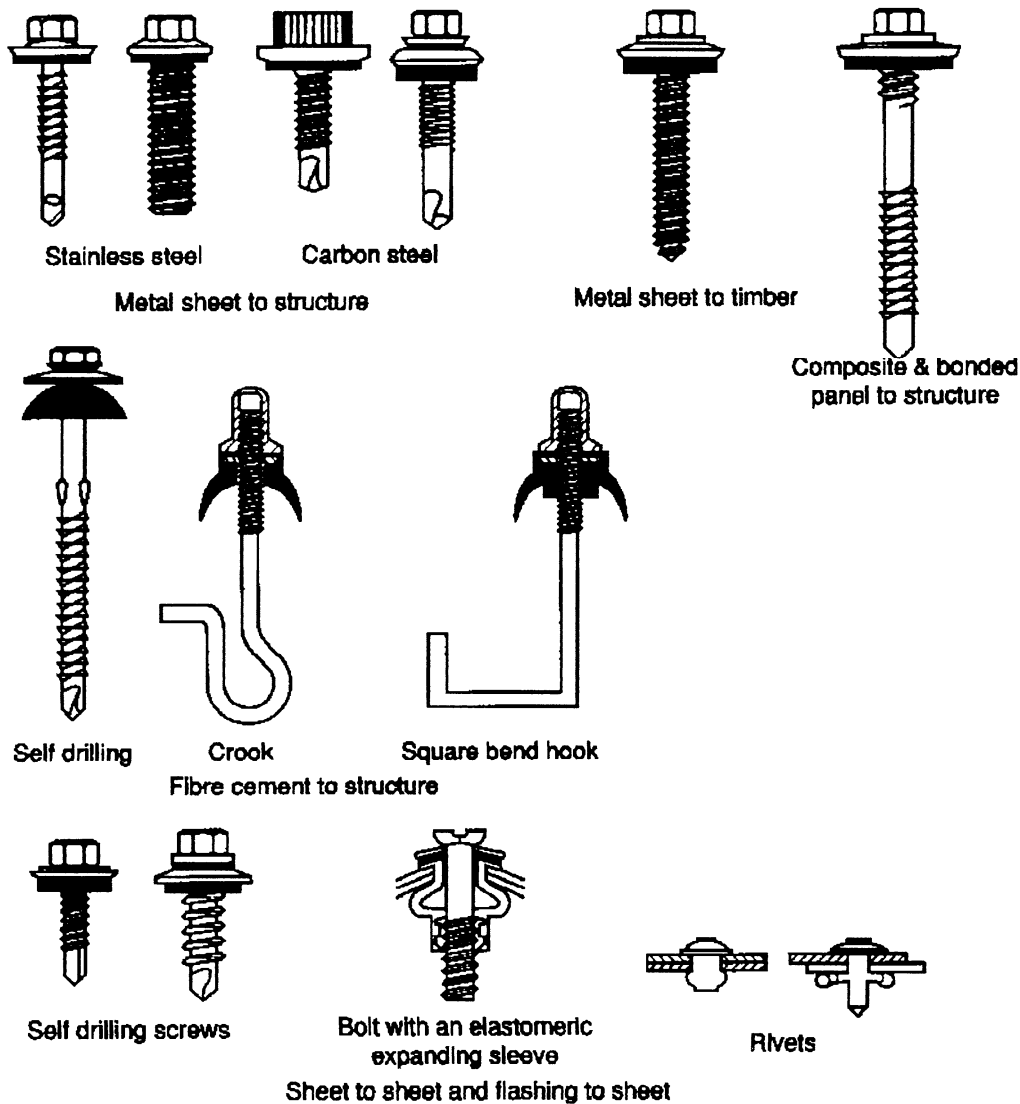
Stainless steel for fasteners should be of grade 304, 305 or 316 of BS 1449-2 or BS 970-1.

Aluminium for fasteners should conform to BS 1494-1.

Heads of fasteners for external cladding may be available in various colours to match the profiled sheeting or supplied with push-fit caps, usually of plastics, of various colours and shapes. Certain types of push-fit caps may provide additional corrosion protection to fasteners, but should not be relied upon as the sole basic protection against corrosion.

NOTE The attention of the user of this Part of BS 5427 is drawn to the restrictions placed on the marketing and use of cadmium and its compounds, contained in the Environmental Protection (Controls of Injurious Substances) (No 4) Regulations 1992.

External



Internal



Figure 2 — Examples of fasteners

2.8.4 Washers

The type, size and stiffness of washers, in relation to the type of fastener are of critical importance in achieving a watertight seal. Their size should be such as to provide a firm uniform seal without damage to the washer, fastener or sheeting, but should not significantly impede rain runoff, particularly in trough fixings.

For crown fixings of corrugated sheeting, shaped crown washers should be used (see BS 1494-1). These provide a greater bearing area and increased resistance to pullover under outward loads.

Saddle washers are often used with crown fixings on trapezoidal profiled sheeting, particularly for aluminium sheeting, so as to increase the fixing strength by providing a larger bearing area for the fastener and increase the uplift resistance of the sheeting. Such washers should have adequate stiffness to develop the required bearing area under load.

Compressible gasket or sealing washers are available in bituminous felt, elastomeric and plastics materials, as separate components for site assembly or as an integral part of the fastener. They should be supported by a rigid washer of suitable size to provide an even and acceptable level of sealing pressure when correctly installed. In certain proprietary washers the rigid and compressible elements are combined as an integral unit, or as part of the fastener.

The materials used should be resistant to the sealing pressure and climatic conditions in service. The washer material should be compatible with the fastener and the sheet and, when plastic, be made from virgin material.

2.8.5 Spacers

Spacer elements are used to maintain the cavity occupied by the insulation or air void in the cladding system. They should consist of the following sections; Z, channel, angle or other section in galvanized steel, stainless steel, aluminium, rectangular timber or fibre cement rails, which may incorporate stools or brackets as a means of creating the required space and may provide for a thermal break. Where plastics stools are used, these should be made from virgin material.

Where metal cladding is used, spacers should be fastened through the liner to purlins or sheeting rails or directly to a structural deck, on one face, and should provide on the other face a supporting and fixing surface for the weatherside sheeting.

NOTE Some fibre cement sheet manufacturers produce proprietary spacers that are sometimes held in position by a clamping action.

Recommendations for design are given in 3.5.5 and recommendations for testing in Annex B.

Proprietary self drilling fasteners are available for composite and bonded panels which combine the function of a fastener and a spacer, and which secure the outer sheeting from subsequent inward displacement under load (see Figure 2).

Spacers are located in the cladding system in a position exposed to interstitial condensation risk. Spacers and associated fasteners should therefore be moisture and corrosion resistant and components should be made of compatible materials. Timber spacers should be preservative-treated, and dried before installation to avoid excessive shrinkage in service. Preservative treatment to timber spacers should be compatible with the sheet and associated materials (see also 3.9).

To avoid loosening due to shrinkage, timber spacers should not be through-fixed to the upper and lower layers, but should be separately fixed to each of these layers.

2.9 Rooflights

Although plastics rooflights are available to match most metal and fibre-cement sheet profiles, the availability of such rooflights conforming to relevant British Standards should be confirmed before specifying.

Plastics rooflights are classified as either thermosetting or thermoplastic. Thermosetting plastics such as GRP pass through a chemical action during manufacture and become permanently set. PVC and polycarbonate are typical thermoplastics which soften when heated and may be remoulded into different shapes after manufacture.

The specifications for material and performance requirements for corrugated sheets are given in BS 4154-1:1985 for translucent GRP sheets and in BS 4203-1:1980 for extruded PVC.

There are no current standards for sheets manufactured from polycarbonate.

Manufacturers should provide evidence of satisfactory performance with regard to manufacturing tolerances, proper nesting of end and side laps with appropriate metal or fibre-cement sheeting, weather-tightness, strength, light transmission, thermal insulation, solar heat input, condensation risk, fire rating and method of fixing.

Rooflights on insulated buildings should be double-skin to reduce heat loss and minimize condensation. These can be site-assembled or factory-manufactured units.

Site assembled rooflights consist of two skins of translucent sheets; the external sheet to conform to the roof sheet profile and a separate inner liner sheet to meet the requirements imposed by the lining material. On factory manufactured units, flat or profiled liners with upstands to form a box are bonded to the underside of the external sheet.

NOTE 1 Site-assembled units are normally used in conjunction with roofing systems incorporating profiled metal liners.

NOTE 2 Factory assembled units are normally used in conjunction with composite panels and over purlin board linings or where fine dust or fumes are likely to be present.

For site-assembled units used in conjunction with sealed metal lining systems, the translucent liner should form an integral part of the vapour sealed liners, and therefore end and side laps should be sealed. The shallow depths of lining panels required to match metal liner may determine purlin centres. It is recommended that closures are used between the sheet skins around the perimeter of the rooflights to prevent the ingress of insulation materials between the translucent panels.

Although factory assembled double-skin units are more rigid than single skin sheets, the manufacturer's recommended purlin centres should not be exceeded as any excessive deflection could strain or weaken bonding joints.

The joints between the factory assembled units and adjacent lining materials should be effectively sealed.

Where high humidities may increase condensation problems, special provision will be required and confirmation of the suitability of rooflights should be obtained from the appropriate manufacturers.

Rooflights cannot be considered as a structural element within a stressed skin construction.

To prevent damage during and after installation, the handling, drilling and fixing of PVC rooflights requires greater care than those made of other materials. The manufacturer's written instructions should therefore be carefully adhered to.

2.10 Rainwater goods

NOTE 1 Table 3 details British Standards for preformed rainwater goods.

Table 3 — Standards for rainwater goods

Material	British Standard
Aluminium	BS 2997
Asbestos cement	BS 569
PVC, unplasticized	BS 4576-1
Galvanized steel	BS 1091
Wrought copper and Wrought zinc	BS 1431

NOTE 2 Although BS 569 covers asbestos cement rainwater goods, the composition of the matrix is generally fibre cement. However, to facilitate compatibility, gutter profiles, accessories and downpipes are manufactured to the dimensions specified in BS 569.

Parapet and valley gutters are usually purpose made to suit the building (see BS 6367). Gutters of these types are commonly made from pregalvanized steel which is protected by a lower mass of zinc than that provided on heavier post-galvanized gutters conforming to BS 1091. Additional site or factory applied protection on the former types would extend their useful life.

Section 3. Design

3.1 General considerations

The design of profiled sheet cladding systems for roofs and walls should take into consideration, but not necessarily be limited to, the following factors:

- a) weathertightness;
- b) strength and rigidity;
- c) thermal insulation;
- d) control of condensation;
- e) control of thermal movement;
- f) sound insulation;
- g) fire resistance and fire precautions;
- h) appearance;
- i) durability;
- j) cost;
- k) daylighting;
- l) external attachments;
- m) lightning protection;
- n) design detailing;
- o) maintenance, remedial work and renewal.

At the design stage consideration should be given to the methodology for erecting and fitting the cladding system on the building during construction. Attention should be paid to risk assessment and health and safety aspects. Any unsupported projection beyond a support should not exceed the manufacturer's recommendations.

Minimum performance requirements for weathertightness, structural stability, thermal insulation, fire precautions and durability are laid down in the Building Regulations (England and Wales), Building Standards (Scotland) Regulations and Building Regulations (Northern Ireland), according to location. Certain design solutions conforming to these standards are given in Approved Documents to the above Regulations. More detailed performance criteria which meet the statutory and other requirements are discussed in this code. Public undertakings and insurance companies may have additional requirements.

In addition to satisfying the performance requirements, the design should involve choosing from many alternative combinations of materials and systems for the profiled sheeting, surface finishes, thermal insulation, condensation control layers and linings, to best suit the technical, financial and aesthetic requirements of the client.

Wherever possible, cladding products and systems should satisfy the relevant performance requirements by reference to appropriate British Standards or established methods of predictive calculations. Where they are not covered by British Standards, evidence of satisfactory performance (such as Agrément Certification) should be sought from the supplier.

The cost of the roof and wall cladding for a typical insulated single storey industrial building forms a significant proportion of the total cost of the building. It is therefore one of the cost-important and multi-functional elements of the building and should be designed with commensurate consideration. In arriving at optimum cost effectiveness, whole life costing should be carried out, taking into account capital, running, maintenance and renewal costs.

Any subsequent painting, sealing or insulation may considerably change the intended performance of the roofing system.

3.2 Weathertightness

3.2.1 Minimum falls on flat roofs

Flat roofs, i.e. those with a finished fall not exceeding 10°, should be designed to avoid ponding of water, so as to reduce the deleterious effect of prolonged soaking on the durability of the sheeting surface. Ponding on rooflights of translucent sheeting also leaves dirt deposits after drying, which are unsightly and impair light transmission. However, some degree of temporary flooding during heavy storms may be permitted where the roof is designed for such conditions (see BS 6367:1983).

To avoid ponding by reverse fall, the deadweight deflection of the profiled sheeting and the reduction in falls due to end laps, seals, dimensional deviations in the profiled sheeting and supporting structure should be taken into account in determining the minimum fall. By geometry alone, the fall required to avoid ponding is 4 times the deflection, D , of a single span sheeting (see Figure 3).

Taking this and other fall-reversing factors into account (such as sheeting straightness tolerance) the supporting structure should be set at a fall of 1.5° more than the minimum fall specified for the sheeting, unless justified by more detailed analysis. For low pitches of 4° or less, only secret-fixed profiles with raised side laps and properly engineered endlaps should be used. Through-fixed profiles are not suitable for such low pitches.

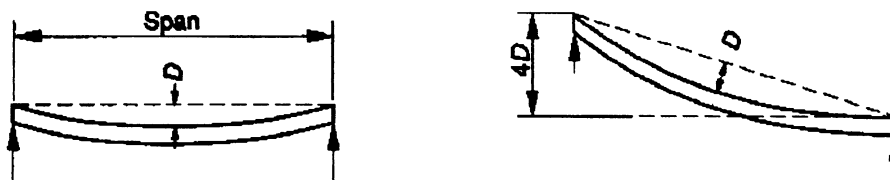


Figure 3 — Minimum fall required to avoid ponding by sheeting deflection

The arrangement of fall directions depends on the roof area, the presence of any expansion joints in the building, the roof shape and drainage capacity and position of gutters and outlets (see BS 6367). Draining to perimeters is generally less liable to the risk of blockage than draining to internal outlets. Where there is a parapet, special details may be necessary to avoid blockage of drain outlets due to build up of debris or of ice and snow.

3.2.2 Weatherproofing properties of profiled sheeting

In selecting profiled sheeting for its weatherproofing properties, the following criteria should be satisfied.

- The sheeting has proven waterproofing performance.
- The profile has adequate capacity to drain the runoff at the relevant roof slope and length from maximum rainfall without immersing the crown.
- The profile can be satisfactorily side-lapped, and where appropriate sealed with sealant, to form joints of adequate watertightness.
- The profile allows fixings to be made to secure the sheeting against dead, imposed and wind loads.

Recommendations for the strength and stiffness of profiled sheeting are given in clause 3.4.

NOTE Profiles for roofs are generally suitable for walls but the reverse may not be true due to the greater drainage capacity required for roof sheeting.

3.2.3 Laps and seals

3.2.3.1 General

Laps in profiled sheeting are locations where rain and wind may penetrate the cladding. Their detailed design and construction are therefore critical to weathertightness.

Laps on pitched roofs and walls resist rain penetration by gravity directing the water flow away from the laps, and by being set at a sufficient slope and lap to avoid ingress of driving rain.

Unsealed laps are air permeable because of gaps, and this may allow water to be driven through the lap during wind conditions when the pressure difference across the lap acts in this direction. For this reason, laps should be as tight fitting as possible, and where necessary closed up by seals and lap stitching. This is particularly important when lapping profiled sheets of the same nominal profile but of different thicknesses, such as when combining metal sheeting with plastics rooflight sheeting, and in such cases the end and side laps should always be sealed.

Sealed laps provide a barrier to both water and air, but are not intended to resist a hydrostatic head of water. Sealants should be placed at an adequate edge distance within the lap to protect them from exposure to sunlight.

Seals should be applied to the under-sheet before the laps are made and not edge sealed afterwards.

For the end and side lapping of proprietary standing seam or secret-fix sheeting systems, the manufacturer's instructions should be consulted.

There are no British Standards for methods of test or acceptance levels for establishing the weathertightness of lapped profiled sheeting. Some indication of resistance to air and rain penetration for wall cladding may be obtained by testing it in accordance with BS 4315-2 and classifying its weathertightness according to BS 6375-1 for windows.

3.2.3.2 Steel and aluminium sheeting

3.2.3.2.1 Roof end laps

At roof pitches at or below 15° end laps should be sealed and stitched.

NOTE Unsealed laps are unlikely to provide adequate weather tightness in UK climatic conditions.

At very low design pitches, less than or equal to 4° , where only secret-fix profiles are suitable, end laps should be avoided by the use of long sheet lengths or should consist of proprietary engineered end laps. The recommended minimum dimension for unsealed end laps is 150 mm; increasing the length enhances weather tightness.

The length of sealed laps should be kept short to avoid opening out under deflection of the sheeting, but should be adequate to accommodate the seal and primary fixing and provide bearing length on the spacer, purlin or sheeting rail. The dimension from primary fixing to the end of the outer sheet should not be less than 50 mm.

Where proprietary systems have special lapping arrangements, the manufacturer's current literature should be consulted.

Where expansion of the profile is accommodated by floating (sliding) end laps, an increased overlap may be necessary and the manufacturer's literature should be consulted. This type of lap may be necessary with aluminium roofing (see also 3.8.2.5).

End laps can be sealed with one or two lines of sealant. When one line of sealant is used, this should be positioned below the fastener line unless the sealant is wide enough for the fasteners to pass through its centre. In this case the sealant should be positioned on the fastener line. When a second line of sealant is used its ideal position will vary with the application of materials used. The profile manufacturer's recommendations should be followed.

3.2.3.2.2 Wall end laps

Wall end laps should be not less than 100 mm when unsealed.

3.2.3.2.3 Roof side laps

The side lap should provide support during fixing and sealing and for foot traffic when installed. The profile shown in Figure 4 is an example of how this may be achieved. For roofs of pitches of 15° or less in severe conditions of exposure, side laps, including those of secret-fix profiles, should be sealed and stitched as recommended by the manufacturers.

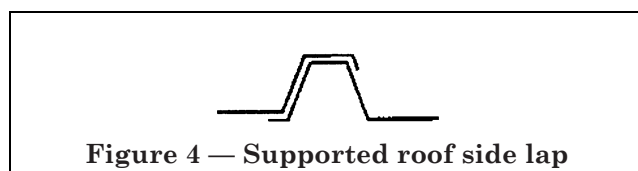


Figure 4 — Supported roof side lap

3.2.3.2.4 Wall side laps

The laps shown in Figure 5 are preferred because the edge of the sheet is away from view.



Figure 5 — Side laps for wall cladding

Side laps are not usually sealed but stitching may be required to maintain closeness of fit. Fire walls should be stitched.

3.2.3.3 Fibre cement sheeting

3.2.3.3.1 End and side laps

The profile of fibre cement corrugated sheets ensures good nesting of end and side laps which minimizes the possibility of water ingress by capillary action. However for roofs of normal (sheltered) exposure at the lowest recommended roof pitches (5° to 15°) both end and side laps should be sealed and, in certain circumstances, a double line of sealant in the end laps will be necessary. For roofs of medium pitch (over 15° up to 22°) the end laps should be sealed or, alternatively, the end laps should be increased from the standard 150 mm to 300 mm so as to eliminate the need for sealing. The manufacturer should be consulted for detailed recommendations.

When forming the end laps there should be a projection of 100 mm below the fixing accessory in 150 mm end laps and from 225 mm to 250 mm in the case of 300 mm end laps.

Sealant should be at least 6 mm diameter (10 mm diameter at the end of rooflights) butyl or polyisobutylene based or similar material which has a rubbery, tacky characteristic and will adhere to both surfaces in end and side laps. In side laps the sealant should be positioned on the crown of the underlapping corrugation and intersect with the end lap sealant on the high point of the mitre outside the fastener.

3.2.3.3.2 Wall end and side laps

The sealing of end laps and side laps in vertical cladding is unnecessary for fibre cement sheets.

3.2.3.4 Plastics rooflights

3.2.3.4.1 General

The mechanical properties of plastics rooflights are different from those of metal and fibre-cement. They have greater flexibility and lower values for "pull-over" failure. The critical conditions for design purpose are those imposed by wind suction.

Fasteners should restrain rooflights without damage when subject to wind gust loadings determined in accordance with CP3:Chapter V-2. Larger washers, of at least 29 mm diameter, are generally required to be used in conjunction with the main sheet fasteners to meet these loadings.

As the thermal movement of plastics rooflights is greater than that of steel, rooflights used in conjunction with metal roofs and fixed over three or more purlins should be progressively secured from one end to prevent possible thermal deflections. It is essential that rooflights are not fixed by first securing the ends and then inserting intermediate fasteners.

To prevent damming of the rainwater flow on roofs when such fasteners are located in the bottom flat of narrow troughs of trapezoidal profiles, the diameter of such washers should be at least 10 mm less than the width of the troughs. Wide trough profiles may require more than one fastener in each trough. When fixing through the crowns of rooflights exceeding 20 mm deep, rigid shaped supports should be located between the rooflights and supporting members to take the pressure required by the sealing washer, without distorting the rooflight profile.

Although the flexibility of plastics rooflights will allow such materials to deflect under loadings without damage to a greater extent than metal or fibre-cement, the effect of more than one load condition should be considered.

- a) At the design wind suction loading, the deflection should be limited to 1/15th of the span and not more than 100 mm to prevent "ovaling" of fixing holes, which could result in failure due to "pullover" or localized cracking.
- b) When subject to imposed snow loads, deflection should not exceed 1/30th of span and not more than 50 mm to avoid the disruption of sealants at end laps.
- c) The deflection of the rooflight's self-load should be considered in relation to roof pitch as any ponding will result in rapid soiling and loss of light transmission.

Rooflights with a minimum overall profile depth of 30 mm can be fixed down to a roof pitch of 5° provided that all laps are adequately sealed. Profiles of less than 30 mm should not be used on pitches less than 10°.

The overhang of GRP should not exceed 250 mm and on PVC and polycarbonate 150 mm. Primary fixings should not be located within 50 mm of the ends of rooflights.

Where PVC and polycarbonate rooflights are installed with rigid fixings in sheet lengths up to 2 m, the diameter of the hole should be 3 mm greater than that of the fastener to allow for movement. On sheets exceeding 2 m, the clearance hole should be increased by 1 mm for each additional metre length. Where flexible fasteners such as synthetic rubber shanked bolts are installed, no additional allowance is required.

PVC rooflights should not overlap dark coloured sheeting. The heat build-up with dark sheets will cause the PVC to discolour or distort. PVC rooflights may be fixed over light coloured sheets, such as white, cream and goose-wing grey. This effect will not occur with GRP or polycarbonate materials.

3.2.3.4.2 End and side laps

NOTE The profiles of plastics rooflights may not be such an exact match as metal-to-metal profiles and additional care is needed in the selection of suitable sealants.

All end and side laps between rooflights and adjacent opaque sheeting should be sealed with a light coloured sealant. Two lines are recommended at end laps, located below the main sheet fasteners. Side laps should be sealed with a single line located at the crown outside of the fixings.

The sealing of laps between translucent rooflights is critical as any ingress of dust or moisture between the rooflights from either internal or external sources will be readily visible. Double sealing such laps with a white or light-coloured proprietary sealant resistant to heat and ultra violet light, located near the edges of the under and overlapping panels, is normally satisfactory but manufacturer's advice should be sought, as such tapes may be required to operate close to their maximum working temperatures.

Side laps should be stitched at centres not exceeding 400 mm. On exposed sites, and on roof pitches below 10°, centres should be reduced to 300 mm.

Stitch fasteners between plastics sheets should be roofing bolts, synthetic rubber grommets or proprietary type fasteners which when assembled will give adequate support on the underside of the sheet. Self-tapping type fasteners and blind head rivets are not considered to provide adequate support and are therefore unsuitable.