

## Kalzip Ltd

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Agrément Certificate

98/3481

Product Sheet 2

## KALZIP STANDING SEAM ROOF SYSTEMS

### KALZIP DECK ROOF SYSTEM

#### PRODUCT SCOPE AND SUMMARY OF CERTIFICATE

This Certificate relates to the Kalzip Deck Roof System, a double skin built-up roof system incorporating standing seam profiled aluminium alloy (coated or uncoated) weathering sheets and accessories for fixing to steel or timber substructures. The system is for use as structural roofing on buildings with finished slopes of between 1.5° and 60° where access is restricted to maintenance and repair only.

#### AGRÉMENT CERTIFICATION INCLUDES:

- factors relating to compliance with Building Regulations where applicable
- factors relating to additional non-regulatory information where applicable
- independently verified technical specification
- assessment criteria and technical investigations
- design considerations
- installation guidance
- regular surveillance of production
- formal three-yearly review.

#### KEY FACTORS ASSESSED

**Structural performance** — when installed and used in accordance with this Certificate, the standing seam profiled sheets will have sufficient strength and stiffness to resist the wind and imposed loads likely to be experienced in the UK (see section 5).

**Weather-tightness** — when installed in accordance with the manufacturer's instructions and this Certificate, the system will be weather-tight within the specified exposure conditions and when used on roofs with finished slopes of between 1.5° and 60° (see section 6).

**Thermal performance** — the system can meet or contribute to meeting the requirements of the national Building Regulations (see section 7).

**Condensation risk** — provided that installation has been carried out correctly and the vapour control layer remains undamaged, the risks of surface and interstitial condensation under normal conditions will be negligible (see section 8).

**Airtightness** — the system will remain reasonably airtight provided that the integrity of the sealing of the deck and vapour control layer is maintained and that other building elements have incorporated appropriate design details and building techniques to prevent air permeability (see section 9).

**Performance in relation to fire** — the standing seam sheets have a notional 'AA'/B<sub>ROOF</sub>(t4) ('low vulnerability' in Scotland) designation as defined in BS 476-3 : 2004 and the deck sheets have a class 'O' or 'low risk' internal surface spread of flame classification (see section 10).



The BBA has awarded this Agrément Certificate to the company named above for the system described herein. This system has been assessed by the BBA as being fit for its intended use provided it is installed, used and maintained as set out in this Certificate.

On behalf of the British Board of Agrément

Handwritten signature of Brian Chamberlain in black ink.

Brian Chamberlain

Head of Approvals — Engineering

Handwritten signature of Greg Cooper in black ink.

Greg Cooper

Chief Executive

Date of First issue: 29 March 2011

Originally certificated on 23 March 1998

*The BBA is a UKAS accredited certification body — Number 113. The schedule of the current scope of accreditation for product certification is available in pdf format via the UKAS link on the BBA website at [www.bbacerts.co.uk](http://www.bbacerts.co.uk)*

*Readers are advised to check the validity and latest issue number of this Agrément Certificate by either referring to the BBA website or contacting the BBA direct.*

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# Regulations

In the opinion of the BBA, the Kalzip Deck Roof System, if used in accordance with the provisions of this Certificate, will meet or contribute to meeting the relevant requirements of the following Building Regulations:



## The Building Regulations 2010 (England and Wales)

<b>Requirement:</b> A1(1)	<b>Loading</b>
Comment:	The system has sufficient strength and stiffness to sustain and transmit the design loads in accordance with sections 5.1 to 5.3 of this Certificate.
<b>Requirement:</b> B2(1)	<b>Internal fire spread (linings)</b>
Comment:	The exposed surfaces (as seen from inside the building) of the deck sheets are unrestricted under this Requirement. See sections 10.1 to 10.3 of this Certificate.
<b>Requirement:</b> B4(2)	<b>External fire spread</b>
Comment:	The external surface of the roofing sheets is unrestricted under this Requirement. See sections 10.1 to 10.3 of this Certificate.
<b>Requirement:</b> C2(b)	<b>Resistance to moisture</b>
Comment:	When installed in accordance with this Certificate and subjected to the maximum design loads given in section 5, the system will resist the passage of moisture to the inside of the building. See sections 6.1 and 6.2 of this Certificate.
<b>Requirement:</b> C2(c)	<b>Resistance to moisture</b>
Comment:	The system poses minimal risk of harmful effects on the building and its occupants arising from interstitial and surface condensation. See sections 8.1 to 8.6 of this Certificate.
<b>Requirement:</b> L1(a)(i)	<b>Conservation of fuel and power</b>
Comment:	When the Certificate holder's standard construction is used, the system can meet or contribute to a construction meeting this requirement. See sections 7.1 to 7.4 and 9.1 to 9.3 of this Certificate.
<b>Requirement:</b> Regulation 7	<b>Materials and workmanship</b>
Comment:	The system is acceptable. See sections 12.1 to 12.9 of this Certificate.



## The Building (Scotland) Regulations 2004 (as amended)

<b>Regulation:</b> 8(1)(2)	<b>Fitness and durability of materials and workmanship</b>
Comment:	Use of the system satisfies the requirements of this Regulation. See sections 11.1 to 11.3, 12.1 to 12.9 and the <i>Installation</i> part of this Certificate.
<b>Regulation:</b> 9	<b>Building Standards – construction</b>
Standard: 1.1(a)(b)	Structure
Comment:	The system has sufficient strength and stiffness to transmit the design load, with reference to clause 1.1.2 <sup>(1)(2)</sup> and 1.1.3 <sup>(1)(2)</sup> . See sections 5.1 to 5.3 of this Certificate.
Standard: 2.1	Compartmentation
Comment:	With reference to clause 2.1.15 <sup>(2)</sup> , the roof finishing details on the internal side of the system have been assessed as having a 'low vulnerability' classification. See sections 10.2 and 10.3 of this Certificate.
Standard: 2.2	Separation
Comment:	With reference to clauses 2.2.10 <sup>(1)</sup> , 2.2.7 <sup>(2)</sup> and 2.1.15 <sup>(2)</sup> , the roof covering has been assessed as having a 'low vulnerability' classification. See sections 10.2 and 10.3 of this Certificate.
Standard: 2.5	Internal linings
Comment:	With reference to clause 2.5.1 <sup>(1)(2)</sup> , the ceiling surfaces (as seen from inside the building) have been assessed as having a 'low vulnerability' classification. See sections 10.2 and 10.3 of this Certificate.
Standard: 2.8	Spread from neighbouring buildings
Comment:	The external roofing sheets have a 'low vulnerability' classification and are not restricted by this Standard, with reference to clause 2.8.1 <sup>(1)(2)</sup> . See sections 10.2 and 10.3 of this Certificate.
Standard: 3.10	Precipitation
Comment:	When subjected to the maximum design load given in this Certificate, the system will resist the passage of moisture to the inside of the building, with reference to clause 3.10.1 <sup>(1)(2)</sup> . See sections 6.1 and 6.2 of this Certificate.
Standard: 3.15	Condensation
Comment:	The system will have minimal risk of surface condensation or of damage due to interstitial condensation, with reference to clauses 3.15.1 <sup>(1)(2)</sup> , 3.15.2 <sup>(1)(2)</sup> , 3.15.3 <sup>(1)(2)</sup> , 3.15.4 <sup>(1)(2)</sup> and 3.15.5 <sup>(1)(2)</sup> . See sections 8.1 to 8.5 of this Certificate.
Standard: 6.1(b)	Carbon dioxide emissions
Standard: 6.2	Building insulation envelope
Comment:	Constructions incorporating the system can meet or contribute to meeting the U values given in all or part of clauses 6.1.1 <sup>(1)(2)</sup> , 6.1.2 <sup>(1)(2)</sup> , 6.1.3 <sup>(1)(2)</sup> , 6.1.4 <sup>(2)</sup> , 6.1.6 <sup>(1)</sup> , 6.1.7 <sup>(1)</sup> , 6.2.1 <sup>(1)(2)</sup> , 6.2.3 <sup>(1)</sup> , 6.2.4 <sup>(1)(2)</sup> , 6.2.5 <sup>(2)</sup> , 6.2.6 <sup>(2)</sup> , 6.2.7 <sup>(1)(2)</sup> , 6.2.9 <sup>(1)(2)</sup> , 6.2.13 <sup>(1)(2)</sup> . See sections 7.1 to 7.4, 9.1, 9.2 and 9.4 of this Certificate.
	(1) Technical Handbook (Domestic).
	(2) Technical Handbook (Non-Domestic).



## The Building Regulations (Northern Ireland) 2000 (as amended)

Regulation:	B2	Fitness of materials and workmanship
Comment:		The system is acceptable. See sections 12.1 to 12.9 and the <i>Installation</i> part of this Certificate.
Regulation:	B3(2)	Suitability of certain materials
Comment:		The system is acceptable. See sections 11.1 to 11.3 of this Certificate.
Regulation:	C4(b)	Resistance to ground moisture and weather
Comment:		When subjected to the maximum design load given in this Certificate, the system will resist the passage of moisture to the inside of the building. See sections 6.1, 6.2 and 8.5 of this Certificate.
Regulation:	C5	Condensation
Comment:		The risk of harmful effects on the building due to interstitial condensation within the system will be minimal. See sections 8.1 to 8.5 of this Certificate.
Regulation:	D1	Stability
Comment:		The system has sufficient strength and stiffness to sustain and transmit the design loads in accordance with sections 5.1 to 5.3 of this Certificate.
Regulation:	E3(a)	Internal fire spread – Linings
Regulation:	E5(b)	External fire spread
Comment:		The system is unrestricted under these Regulations. See sections 10.1 and 10.3 of this Certificate.
Regulation:	F2(a)(i)	Conservation measures
Regulation:	F3(2)	Target carbon dioxide Emissions Rate
Comment:		The system can meet or contribute to a construction meeting the U values given in sections 7.1 to 7.3, 9.1, 9.2 and 9.5 of this Certificate.

### Construction (Design and Management) Regulations 2007

### Construction (Design and Management) Regulations (Northern Ireland) 2007

Information in this Certificate may assist the client, CDM co-ordinator, designer and contractors to address their obligations under these Regulations.

See section: 2 *Delivery and site handling* (2.1 and 2.2) of this Certificate.

## Non-regulatory Information

### NHBC Standards 2011

NHBC accepts the use of the Kalzip Deck Roof System, when installed and used in accordance with this Certificate, in relation to *NHBC Standards, Part 7 Roofs, Chapter 7.2 Pitched roofs*.

## General

The system is weathertight and structurally stable within the limits set out in this Certificate and is intended to be fixed to steel, aluminium or timber rafters.

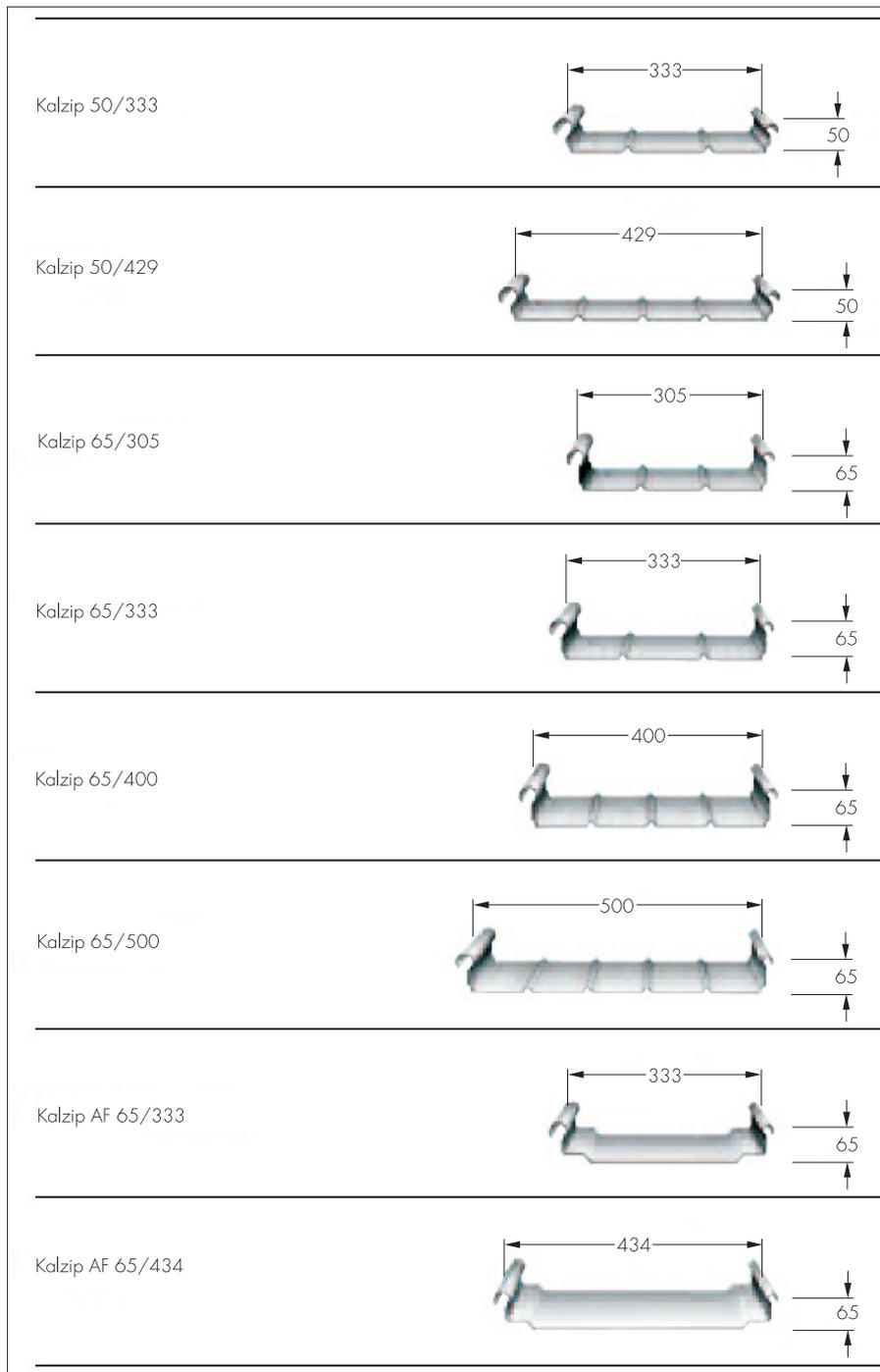
## Technical Specification

### 1 Description

1.1 The Kalzip Deck Roof System consists of a covering of interlocking profiled sheets attached to profiled roof decking by special clips fixed by mechanical fasteners. The profiled decking is in turn attached directly to the roof substructure. Visible through-fixings of the roof sheeting are not required. Typical roof make-up is described in section 1.8.

1.2 The outer standing seam sheet is of aluminium, rolled to the profiles and dimensions shown in Figure 1, and is available in straight, convex, concave and tapered forms. All profiles, apart from Kalzip AF, incorporate full length stiffening ribs along the flat section of the sheet.

Figure 1 Kalzip standing seam profiles (dimensions in millimetres)



1.3 Profiles are manufactured from aluminium alloys in various finishes to BS EN 485-1 : 2008 and BS EN 1396 : 2007:

- non-clad aluminium alloys to EN AW-3004 or EN AW-3005 in standard stucco embossed finish
- clad or 'pre-weathered' (AluPlusPatina) aluminium alloys to EN AW-3004 or EN AW-6025 in standard stucco embossed finish clad with EN AW-7072 to approximately 4% thickness on both sides
- plated aluminium alloys (AluPlusZinc in accordance with BBA Certificate 08/4571) to EN AW-3004 with approximately 4 µm pre-weathered (phosphate) zinc plating to both sides
- coil coated aluminium alloys (PVDF [PVF<sub>2</sub>], polyester or ARS in accordance with BBA Certificate 93/2922) to EN AW-3004 or EN AW-3005, available in a range of colours.

1.4 The profiles are available in thicknesses of 0.7 mm, 0.8 mm, 0.9 mm, 1.0 mm or 1.2 mm. It is possible to factory produce sheets up to 50 m in length but this would be dependent upon transport and site access. Sheets over 27 m in length are normally roll-formed on site using mobile roll-formers.

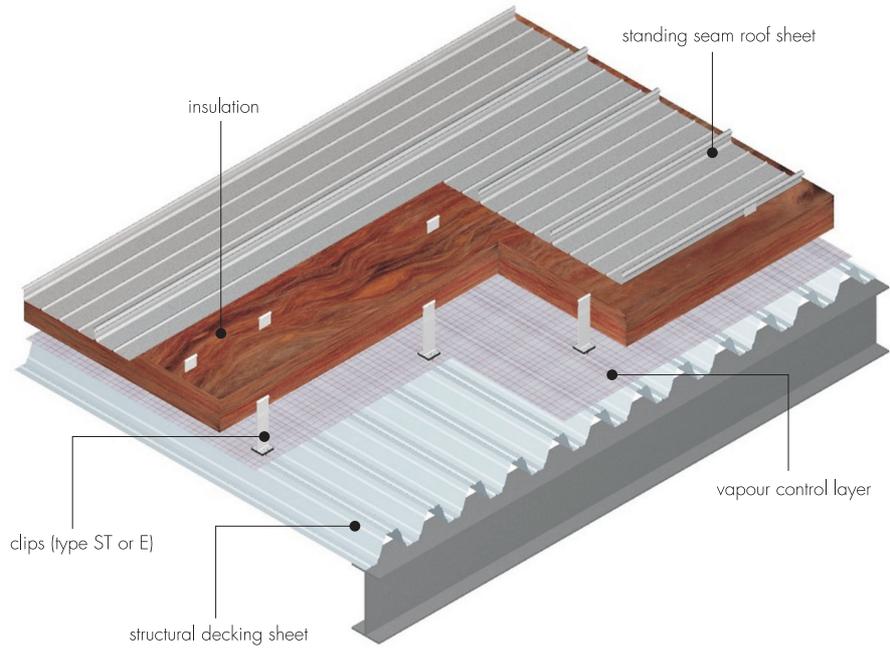
1.5 The underlining decking consists of Kalzip structural deck sheets, manufactured from coated or uncoated galvanized structural steel to BS EN 10346 : 2009 or aluminium alloy to BS EN 485-1 : 2008 or BS EN 1396 : 2007. The decking is designed to span rafters and obviates the need for a purlin structure. The spanning capabilities can be determined from the Certificate holder's published load/span tables.

1.6 Components bought-in to defined specification and used with the system include:

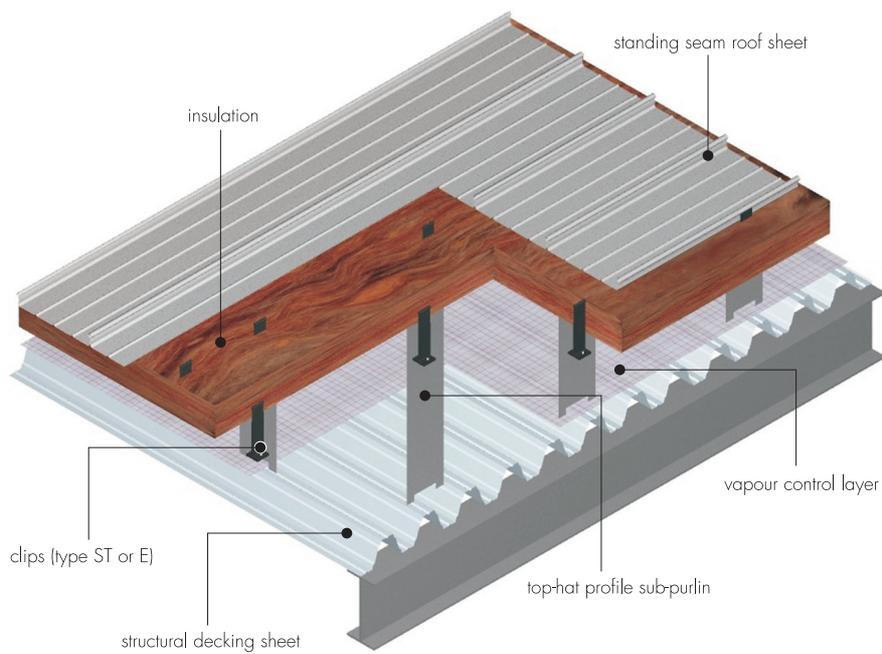
- Kalzip clips — used to support the standing seam roof sheets and attach them to the structure/sub-structure. There are two types:
    - type ST, manufactured from aluminium alloy to EN AW-6060 or EN AW-6061 and in accordance with BS EN 755-1 : 2008, and used in conjunction with either TK5 (5 mm thick) or TK15 (15 mm thick) purpose made polyamide thermal barrier pads (thickness determined by thermal performance required). The clips are available in a range of heights from 66 mm to 246 mm and are pre-drilled with 6 holes in the base for fastening to the steel/aluminium decking
    - type E, manufactured from polyamide reinforced with galvanized steel (minimum grade S320 GD + AZ185) to BS EN 10346 : 2009. The clips themselves are designed to act as a thermal barrier and are available in a range of heights from 66 mm to 241 mm. Polyamide spacers (5 mm and 10 mm thick) may be used in conjunction with the clips
  - fixings for Kalzip clips — 6 mm diameter austenitic stainless steel (AISI Grade 304) anti-torque self-drilling for fixing to structural decking or steel/aluminium sub-purlins, 4.8 mm diameter aluminium Bulbtite rivets with EPDM washers for fixing to structural decking, or 5.5 mm, 5.8 mm or 6.3 mm diameter austenitic stainless steel (AISI grade 304) self-tapping or self-drilling fasteners, complete with stainless steel or aluminium/EPDM bonded washers, for fixing to steel/aluminium sub-purlins
  - filler blocks for eaves, ridge and deck — manufactured from closed-cell cross-linked polyethylene foam (minimum density 30 kg·m<sup>-3</sup>), closed-cell EPDM (minimum density 150 kg·m<sup>-3</sup>) or closed-cell cross-linked polyethylene foam faced with EPDM (minimum overall density 40 kg·m<sup>-3</sup>)
  - ridge components — comprising spacer profiles, flat spacer bars and sliding ridge clips manufactured from extruded aluminium alloy, and ridge closures fabricated in aluminium from similar material and to similar finish as the respective standing seam sheets. Fixings are 4.8 mm diameter aluminium blind sealed type rivets with stainless steel mandrels
  - eaves components — comprising drip angles manufactured from extruded aluminium alloy. Fixings are 4.8 mm diameter aluminium blind sealed type rivets with stainless steel mandrels
  - verge (gable) components — comprising extruded aluminium alloy gable end hooks, gable end channels and tolerance gable profiles. Fixings are austenitic stainless steel (AISI Grade 304) 6.3 mm diameter self-tapping or self-drilling fasteners with stainless steel or aluminium/EPDM bonded washers (gable end hooks to gable end ST clips), 4.8 mm diameter aluminium Bulbtite rivets (gable end hooks to gable end E clips) and 4.8 mm diameter aluminium blind sealed type rivets with stainless steel mandrels (gable end channel to Kalzip seam)
  - vapour control layer<sup>(1)</sup> — available in a number of types, including:
    - Kalzip VCL Foil, aluminium foil encased in reinforced virgin polyethylene with an overall thickness of 0.3 mm
    - Kalzip VCL Clear, reinforced polyethylene with an overall thickness of 0.25 mm
    - Kalzip Economy VCL, reinforced polyethylene with an overall thickness of 0.2 mm
    - Kalzip Lowcon VCL, reinforced polyethylene with an overall thickness of 0.2 mm.
- (1) The vapour control layers are sealed with Kalzip VCL Sealant Tape (butyl rubber sealant) or Kalzip Economy Sealant Tape (synthetic, rubber-based, double-sided strip). The choice of VCL and sealant is determined by the humidity class of the building and the type of deck used (the Certificate holder should be contacted for further advice).
- insulation<sup>(2)</sup> — conforming to BS EN 13162 : 2008, BS 476-4 : 1984, BS EN ISO 1182 : 2002, and A1 classification to BS EN 13501-1 : 2007 and available in a number of types, including:
    - Kalzip Insulation Plus 40, glass-fibre quilt with  $\lambda_{90/90}$  value of 0.040 W·m<sup>-1</sup>·K<sup>-1</sup>
    - Kalzip Insulation Plus 37, glass-fibre quilt with  $\lambda_{90/90}$  value of 0.037 W·m<sup>-1</sup>·K<sup>-1</sup>
    - Kalzip Insulation Plus 35, glass-fibre quilt with  $\lambda_{90/90}$  value of 0.035 W·m<sup>-1</sup>·K<sup>-1</sup>
    - Kalzip Insulation Plus 32, glass-fibre quilt with  $\lambda_{90/90}$  value of 0.032 W·m<sup>-1</sup>·K<sup>-1</sup>
    - Kalzip Rockfibre Quilt 40, rock-fibre quilt with  $\lambda_{90/90}$  value of 0.040 W·m<sup>-1</sup>·K<sup>-1</sup>
    - Kalzip Rockfibre Slab 140, rock-fibre slab with  $\lambda_{90/90}$  value of 0.035 W·m<sup>-1</sup>·K<sup>-1</sup>.
- (2) The type and thickness of insulation to be used in a roof system is determined by the thermal transmittance (U value) requirements for each project.
- Kalzip Top-Hat Profile sub-purlins — manufactured from galvanized mild steel (minimum grade S220 GD + Z275 to BS EN 10346 : 2009) with a minimum thickness of 1.5 mm and aluminium alloy (minimum 0.2% proof stress of 180 N·mm<sup>-2</sup>) with a minimum thickness of 2 mm. Aluminium should be used for buildings likely to experience high internal relative humidities (eg building internal humidity Class 5)
  - sealant — gun-applied, elastic, waterproof, non-corrosive, low modulus silicon rubber type, supplied or approved by the Certificate holder.

1.7 Flashings, made to order of the same material and finish as Kalzip standing seam and Kalzip structural decking sheets and used in such places as verge, ridge and eaves, are also available but are outside the scope of this Certificate.

1.8 Details of typical installations, showing the various components *in situ*, are shown in Figure 2.



(a) Kalzip clips fixed direct to structural decking sheet



(b) Kalzip clips fixed to top hat profile sub-purlin mounted on structural decking sheet

1.9 When used in other assemblies, the full system performances given in this Certificate cannot be assumed. The Kalzip profiles' structural details, fire performance and durability, as described in this Certificate, will apply but the designer must be satisfied on other aspects of performance, eg thermal insulation, risk of condensation and acoustic properties. The Certificate holder should be contacted for further advice.

1.10 Openings to details, such as vents and PVC or GRP rooflights can be incorporated in the Kalzip system but are outside the scope of this Certificate.

1.11 The filler pieces for the eaves and the ridge are bought-in to the Certificate holder's specification and are subject to visual and dimensional quality control checks.

## 2 Delivery and handling

2.1 Factory produced Kalzip sheets of the required length are delivered to site on pallets, each carrying a label bearing the BBA identification mark incorporating the number of this Certificate. Loads must not project more than 4 m at each end. When lifting pallets, the braces or ropes must have edge protection. A spreader beam must be used to unload lengths exceeding 12 m. If the sheets are not required immediately, the pallets should be stored on firm, level ground, preferably under cover and in dry, dust-free conditions with adequate ventilation. Pallets must not be stacked.

2.2 Profiles can be produced on site using Kalzip mobile roll-formers. Completed sheets can be packed, banded and positioned near the work area either by lifting or via a ramp. When being carried, completed lengths should be supported by one operative at a maximum of every 7 metres.

2.3 The durability of a roof system will depend on the deck sheets and vapour control layer being undamaged before or during installation. Handling and storage of these items, therefore, should be in accordance with the following guidelines:

- decking sheets should be handled in the same way as factory produced Kalzip sheets
- rolls of vapour control layer must be handled carefully to avoid puncturing and to prevent damage, and must not be stored on end. For long-term storage, the rolls should be protected from ultraviolet light, either indoors or under opaque covers. The vapour control layer should be dry during installation
- insulation is delivered to site in individual polythene wrapped rolls or in multiples in Supakubes (a palletised bulk polyethylene wrapper with weatherproof hood covering the insulation and the pallet). Rolls delivered separately or taken out of the Supakube wrapping should be stored indoors or under a waterproof covering.

## Assessment and Technical Investigations

The following is a summary of the assessment and technical investigations carried out on the Kalzip Deck Roof System.

### Design Considerations

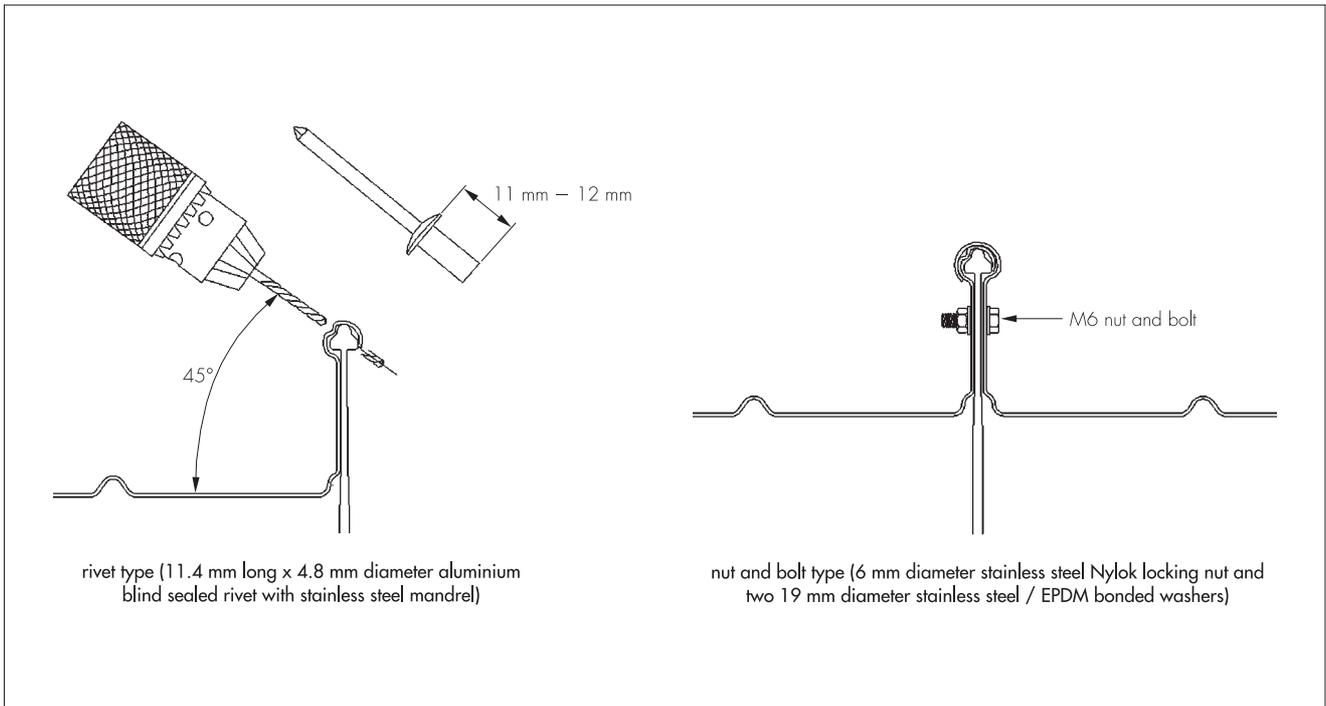
## 3 General

3.1 The Kalzip Deck Roof System is satisfactory for use as a structural roof system, with slopes from 1.5° to 60°, where access is required for maintenance and repair only.

3.2 If architectural features, through fittings or rooflights are required in the roof structure, special care and attention is necessary, in common with all metal roofs, to ensure that these features have been correctly detailed and fitted.

3.3 A fixed point should be designed into the roof, normally at the ridge although in some cases it may be at the eaves or mid-point of the roof slope. The anticipated loading of this fixed point is calculated based on the roof slope, roof loading and type and thickness of Kalzip standing seam profile utilised, and the appropriate fixed point fixing method determined, using rivets or bolts (see Figure 3). The Certificate holder should be contacted for further advice.

Figure 3 Typical Kalzip fixed point types



## 4 Practicability of installation

The system should only be installed by installers who have been trained and approved by the Certificate holder.

## 5 Structural performance



5.1 Kalzip standing seam profiled sheets have adequate strength and stiffness to sustain specified loads when used in accordance with this Certificate. Load/span values are given in Table 1 and should be used to confirm that the proposed specification is adequate to resist the design loads (see section 5.2) based on the span (see Table 1, footnote 3).

5.2 When evaluating the design loads, wind loads must be calculated in accordance with the recommendations of BS EN 1991-1-4 : 2005, and the imposed snow loads must be calculated in accordance with the recommendations of BS EN 1991-1-3 : 2003.

5.3 Kalzip standing seam profiled sheets are capable of withstanding impacts associated with normal handling, installation and service.

5.4 The Kalzip Deck Roof System is capable of accommodating thermal movement of the outer sheets provided it is installed in accordance with this Certificate and the Certificate holder's instructions.

## 6 Weathertightness



6.1 When installed in accordance with the manufacturer's instructions and this Certificate, the system is weathertight when used on roofs with finished slopes of between 1.5° and 60° and within exposure conditions related to recommended maximum design wind pressures.

6.2 The weathertightness of the system will not be adversely affected by normal service deflections.

Table 1 Maximum permissible snow and wind loads (kN·m<sup>-2</sup>)

**ST CLIPS**

Kalzip Profile	Thickness (mm)	Span (m)									
		Wind suction loads (kN·m <sup>-2</sup> )					Imposed (eg snow) loads (kN·m <sup>-2</sup> )				
		1.0	1.5	2.0	2.5	3.0	1.0	1.5	2.0	2.5	3.0
50/333	0.9	5.009	3.110	1.839	1.218	0.868	6.863	3.509	2.022	1.292	0.776
	1.0	6.174	4.124	2.533	1.653	1.166	6.860	4.134	2.391	1.515	0.861
	1.2	6.920	4.513	2.785	1.897	1.379	6.853	4.555	2.734	1.734	1.033
50/429	0.9	3.891	2.549	1.508	0.999	0.713	5.322	3.269	1.892	1.119	0.634
	1.0	4.964	3.315	2.072	1.353	0.955	5.319	3.535	2.240	1.240	0.702
	1.2	5.375	3.591	2.283	1.556	1.132	5.312	3.528	2.609	1.485	0.841
65/305	0.9	6.280	4.194	2.611	1.736	1.219	7.493	4.984	3.449	2.195	1.514
	1.0	8.032	5.363	3.338	2.204	1.566	7.490	4.980	3.726	2.552	1.713
	1.2	9.363	6.252	4.355	2.836	1.996	7.482	4.973	3.718	2.965	2.057
65/333	0.9	5.908	3.946	2.498	1.661	1.168	6.861	4.563	3.294	2.096	1.446
	1.0	7.554	5.044	3.195	2.110	1.501	6.858	4.560	3.410	2.431	1.609
	1.2	8.885	5.933	4.165	2.712	1.910	6.850	4.552	3.403	2.714	1.932
65/400	0.9	5.080	3.394	2.221	1.480	1.047	5.708	3.795	2.838	1.844	1.257
	1.0	6.493	4.336	2.846	1.883	1.340	5.705	3.791	2.835	2.143	1.397
	1.2	7.611	5.083	3.730	2.431	1.713	5.698	3.784	2.828	2.254	1.677
65/500	0.9	3.832	2.562	1.805	1.206	0.866	4.562	3.031	2.266	1.473	1.014
	1.0	4.895	3.271	2.327	1.543	1.101	4.559	3.028	2.263	1.715	1.172
	1.2	5.753	3.844	2.890	2.000	1.411	4.552	3.021	2.256	1.797	1.404
AF 65/333	0.9	3.893	2.601	1.955	1.366	0.959	6.863	4.319	2.589	1.718	1.183
	1.0	5.018	3.353	2.465	1.655	1.156	6.860	4.383	2.732	1.865	1.352
	1.2	6.329	4.227	3.176	2.301	1.674	6.853	4.555	3.062	2.094	1.520
AF 65/434	0.9	2.990	1.999	1.503	1.110	0.781	5.261	3.498	2.169	1.442	0.997
	1.0	3.999	2.672	2.008	1.345	0.941	5.258	3.494	2.272	1.553	1.127
	1.2	4.860	3.247	2.441	1.869	1.361	5.251	3.488	2.549	1.745	1.267

**E CLIPS**

Kalzip Profile	Thickness (mm)	Span (m)									
		Wind suction loads (kN·m <sup>-2</sup> )					Imposed (eg snow) loads (kN·m <sup>-2</sup> )				
		1.0	1.5	2.0	2.5	3.0	1.0	1.5	2.0	2.5	3.0
50/333	0.9	3.433	2.294	1.725	1.218	0.868	4.984	3.312	2.022	1.292	0.776
	1.0	4.420	2.953	2.220	1.653	1.166	4.981	3.309	2.391	1.515	0.861
	1.2	6.526	4.358	2.785	1.897	1.379	4.974	3.302	2.466	1.734	1.033
50/429	0.9	2.668	1.784	1.342	0.999	0.713	3.864	2.566	1.892	1.119	0.634
	1.0	3.434	2.296	1.726	1.353	0.955	3.860	2.563	1.914	1.240	0.702
	1.2	5.069	3.387	2.283	1.556	1.132	3.854	2.556	1.907	1.485	0.841
65/305	0.9	4.178	2.792	2.099	1.683	1.219	6.311	4.196	3.138	2.195	1.514
	1.0	5.328	3.559	2.675	2.144	1.566	6.307	4.192	3.135	2.500	1.713
	1.2	7.125	4.758	3.575	2.836	1.996	6.300	4.185	3.127	2.492	2.057
65/333	0.9	3.828	2.558	1.923	1.542	1.168	5.779	3.841	2.873	2.096	1.446
	1.0	4.881	3.261	2.451	1.965	1.501	5.775	3.838	2.869	2.288	1.609
	1.2	6.527	4.360	3.276	2.626	1.910	5.768	3.830	2.862	2.280	1.893
65/400	0.9	3.189	2.132	1.603	1.286	1.047	4.807	3.194	2.388	1.844	1.257
	1.0	4.066	2.717	2.043	1.638	1.340	4.803	3.190	2.384	1.900	1.397
	1.2	5.437	3.632	2.730	2.189	1.713	4.796	3.183	2.377	1.893	1.571
65/500	0.9	2.554	1.708	1.285	1.031	0.862	3.841	2.551	1.906	1.473	1.014
	1.0	3.255	2.176	1.637	1.313	1.097	3.838	2.547	1.902	1.515	1.172
	1.2	4.353	2.909	2.187	1.754	1.411	3.831	2.541	1.896	1.509	1.250
AF 65/333	0.9	4.024	2.689	2.014	1.366	0.959	2.723	1.805	1.346	1.070	0.887
	1.0	5.018	3.353	2.465	1.655	1.156	4.742	3.150	2.354	1.865	1.352
	1.2	6.391	4.270	3.210	2.301	1.674	4.735	3.143	2.347	1.869	1.520
AF 65/434	0.9	3.090	2.066	1.553	1.110	0.781	2.084	1.380	1.028	0.816	0.675
	1.0	4.050	2.706	2.008	1.345	0.941	3.633	2.411	1.800	1.434	1.127
	1.2	5.201	3.476	2.614	1.869	1.361	3.626	2.405	1.794	1.427	1.183

Notes:

- All loads are assumed to be applied uniformly and apply to multiple span conditions, ie three spans or more.
- The self-weight of the Kalzip sheeting has been taken into account in the above loadings.
- Deflection limits are L/90 (wind suction loads) and L/200 (imposed loads).
- The following load and material factors have been taken into account in the design capacity of the sheeting:

dead load	1.35	dead load (restraining wind uplift)	1.00
snow load	1.50	attachment resisting wind uplift	2.00
wind load	1.50	material factor	1.10
- All spans are assumed to be equal to or within 15% of the largest span.
- The above imposed loadings are applicable for Kalzip sheets with ST L.190 clips or below and E.180 clips or below in their respective Tables.
- For other loading conditions, the advice of the Certificate holder should be sought.
- Structural design of all fasteners must be in accordance with the Certificate holder's recommendations.

## 7 Thermal performance



7.1 The thermal performance of each building incorporating the roof system must be evaluated in accordance with the relevant Building Regulations, and is the responsibility of the overall designer of the building.

7.2 The U value of a Kalzip Deck Roof System is dependent on a number of variables, such as clip type, clip frequency (based on clip/sub-purlin centres and sheet cover-width), insulation type and insulation depth (based on clip height, seam height and sub-purlin height, if applicable). Some examples of typical U values for Kalzip Deck Roof Systems calculated in accordance with BS EN ISO 10211 : 2007 are given in Table 2.

Table 2 Typical U values<sup>(1)(2)</sup> ( $W \cdot m^{-2} \cdot K^{-1}$ )

Roof system	Clip type	Insulation depth (mm)	Insulation conductivity, $\lambda_{90/90}$ value ( $W \cdot m^{-1} \cdot K^{-1}$ )			
			0.040	0.037	0.035	0.032
Kalzip 65/400 Deck Roof	ST. L190 with TK15	200	0.25	0.24	0.23	0.21
	E.180	180	0.21	0.20	0.19	0.18
Kalzip 50/429 Deck Roof	ST. L190 with TK15	215	0.24	0.22	0.22	0.20
	E.180	195	0.20	0.19	0.18	0.16
Kalzip 65/400 Deck Roof with 30 mm top-hat sub-purlin	ST. L190 with TK15	230	0.23	0.22	0.21	0.20
	E.180	210	0.19	0.18	0.17	0.16
Kalzip 50/429 Deck Roof with 30 mm top-hat sub-purlin	ST. L190 with TK15	245	0.22	0.21	0.20	0.19
	E.180	225	0.18	0.17	0.16	0.15

(1) With a clip frequency of 1.5 per m<sup>2</sup>.

(2) For U value calculations for individual projects, the Certificate holder's advice should be sought.

7.3 The roof system contributes to meeting the requirements of the national Building Regulations thus:

### England and Wales

- roofs, subject to system type and clip frequency, can achieve (see Table 3):

Table 3 Mean design roof U values – England and Wales<sup>(1)</sup>

Construction	U value ( $W \cdot m^{-2} \cdot K^{-1}$ )
Notional dwelling	0.16
Existing building – new, replaced, renovated or retained roof	0.18
Notional non-domestic building	0.18
Dwelling new-build limit	0.20
Non-domestic new-build limit	0.25

(1) Flexible approaches on existing buildings are given in the Approved Documents.

### Scotland

- roofs, subject to system type and clip frequency, can achieve (see Table 4):

Table 4 Mean design roof U values – Scotland<sup>(1)</sup>

Construction	U value ( $W \cdot m^{-2} \cdot K^{-1}$ )
Notional dwelling	0.13
New dwelling simplified method	0.13
Conversion unheated building (into dwellings)	0.15
Extension to dwelling	0.15
New non-dwellings limit for shell and fit-out	0.15
Conversion of unheated building	0.15
Non-domestic extension, alterations and reconstructions	0.15
Notional non-dwelling (pitched roof)	0.16
Alterations and reconstructions to a dwelling	0.18
Stand alone building < 50 m <sup>2</sup> to a dwelling	0.18
Notional non-dwelling	0.18
New dwelling limit	0.20
New non-domestic limit	0.25
Conversion of heated building	0.25

(1) Flexible approaches on existing buildings are given in the Technical Handbooks.

### Northern Ireland

- roofs, subject to system type and clip frequency, can achieve (see Table 5):

Table 5 Mean design roof U values – Northern Ireland<sup>(1)</sup>

Construction	U value (W·m <sup>-2</sup> ·K <sup>-1</sup> )
Notional dwelling	0.16
Existing building – New roof	0.20
Building new-build limit	0.25
Notional non-domestic building	0.25
Existing building – replaced, renovated or retained roof	0.25

(1) Flexible approaches on existing buildings are given in the Technical Booklets.



7.4 The effect of thermal bridging at the junctions between the systems and other building elements, such as walls, and around openings such as rooflights, must be minimised. The performance of these junctions will be dependent upon building elements not covered by this Certificate. A suitable assessment of all junction details should be carried out.

## 8 Condensation risk



8.1 In common with all metal roof constructions, there is a risk of condensation that can arise either as interstitial condensation within the roof construction or as surface condensation at thermal bridging.

### Surface condensation



8.2 The internal temperature at which surface condensation will occur on the internal surfaces of the roof is dependent on both the internal relative humidity and the external temperature. It has been shown by computer modelling that the risk of condensation occurring on the internal surfaces is negligible.

8.3 In buildings likely to experience high internal relative humidities (eg building internal humidity classes 4 and 5 as defined in BS 5250 : 2002 and BS EN ISO 13788 : 2002) there is a minimal risk of intermittent condensation forming on the fixing screws penetrating the deck with some variations of Kalzip Deck Roof Systems (see section 8.4). The designer should anticipate the areas of the structure that could be at risk from sustained sources of humidity and take the necessary measures to prevent such problems (see section 8.6).

8.4 To ensure surface condensation is minimised and mould growth avoided, the temperature factor ( $f_{rsi}$ ) (defined in BS EN ISO 13788 : 2002) should be taken into consideration and used in conjunction with details given in BRE Information Paper IP 1/06 *Assessing the effects of thermal bridging at junctions and around openings* to assess the conditions required of the building involved. To assist with this, example temperature factors calculated in accordance with BS EN ISO 10211 : 2007 for different insulation thicknesses and conductivities and taking account of the fixings are given in Table 6.

Table 6 Example temperature factors<sup>(1)</sup>

Roof system	Clip type	Insulation depth (mm)	Insulation conductivity, $\lambda_{90/90}$ value (W·m <sup>-1</sup> ·K <sup>-1</sup> )			
			0.040	0.037	0.035	0.032
Kalzip Deck Roof	ST. L190 with TK15	200	0.65	0.65	0.65	0.65
	E.180	180	0.92	0.92	0.92	0.92
Kalzip Deck Roof with 30 mm top-hat sub-purlin	ST. L190 with TK15	230	0.91	0.91	0.91	0.91
	E.180	210	0.95	0.95	0.95	0.95

(1) For temperature factor calculations for individual projects, the Certificate holder's advice should be sought.

### Interstitial condensation



8.5 Computer modelling predicts that, for buildings in internal humidity classes 1 to 4 (see Table 7), interstitial condensation is unlikely to be a significant problem under the normal climatic conditions experienced in the UK, provided the deck and vapour control layer (VCL) remain adequately sealed and are correctly installed and undamaged (see section 14).

Table 7 Internal humidity classes

Humidity class <sup>(1)</sup>	Building types
1	Storage areas
2	Offices, shops
3	Dwellings with low occupancy
4	Dwellings with high occupancy, sports halls, kitchens, canteens; buildings heated with un-flued gas heaters
5	Special buildings, eg laundries, breweries, swimming pools

(1) As referenced in BS EN ISO 13788 : 2002 and BS 5250 : 2002.



8.6 For buildings in internal humidity class 5 and in buildings or areas of buildings with special internal design conditions, a hygrothermal assessment of the proposed roof system should be undertaken using the guidance given in BS 5250 : 2002, BS 5925 : 1991 and BS 6229 : 2003, to establish whether special provisions, such as additional ventilation or air conditioning within the building, are required to maintain the internal conditions within acceptable limits. Advice should be sought from the Certificate holder.

## 9 Airtightness



9.1 The airtightness of the system is reliant on the careful sealing of the liner and vapour control layer, and on maintaining the integrity of the seal throughout. In addition to sealing at all joints, the liner and VCL must be sealed at the perimeter and all penetrations. Details of sealing at all laps, eaves, hips, valleys and penetrations must be in accordance with the Certificate holder's instructions.

9.2 The airtightness of the building will also be dependent on the performance of other building elements. Provided these also incorporate appropriate design details and building techniques, air infiltration through the building fabric should be minimal and the building reasonably airtight.



9.3 Completed buildings in England and Wales are subject to pre-completion testing for airtightness in accordance with the requirements of Approved Document L1A and L2A, section 20B.



9.4 Completed buildings in Scotland are subject to the 2007 Accredited Construction Details for airtightness testing if the target air permeability of the building is less than  $10 \text{ m}^{-3} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$  or if the figure is between  $10 \text{ m}^{-3} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$  and  $15 \text{ m}^{-3} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$  and the designer does not wish to use the  $15 \text{ m}^{-3} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$  default figure, in accordance with Mandatory Standard 6.2, clauses 6.2.5<sup>(1)</sup> and 6.2.6<sup>(2)</sup>.

(1) Technical Handbook (Domestic).

(2) Technical Handbook (Non-Domestic).



9.5 In Northern Ireland, completed buildings are subject to pre-completion testing for airtightness in accordance with the requirements of Technical Booklets F1, sections 2.46 to 2.54, and F2, sections 2.57 to 2.61.

9.6 Air leakage design test data are available from the Certificate holder.

## 10 Performance in relation to fire



10.1 The Kalzip sheets have a notional designation of AA/B<sub>ROOF</sub>(t4), as defined in Appendix A, Table A5 of Approved Document B to The Building Regulations 2010 (England and Wales) and in Technical Booklet E, Table 4.6 of the Building Regulations (Northern Ireland) 2000 (as amended), and may be used as a roofing covering within 6 metres of any boundary.



10.2 The Kalzip sheets have a notional 'AA' ('low vulnerability'<sup>(1)(2)</sup> in Scotland) designation as defined by BS 476-3 : 2004.

10.3 The Kalzip deck sheets are deemed to have a Class 'O' or 'low risk'<sup>(1)(2)</sup> internal surface spread of flame as defined in the national Building Regulations.

(1) Technical Handbook (Domestic), Annexes 2B and 2C.

(2) Technical Handbook (Non-Domestic), Annexes 2E and 2F.

## 11 Maintenance



11.1 The system should be inspected regularly (at least once a year) for accidental damage to the roof sheets or their coatings and also for any build-up of dirt and debris. Damage must be repaired and accumulated dirt and debris removed. The frequency of inspections will depend on the environment and use of the building.

11.2 In industrial and coastal areas it may be necessary to clean the installation periodically by hosing with water and a neutral detergent to restore its appearance and to remove corrosive deposits. It may be necessary to clean soffits in any environment.

11.3 Damaged sheets can be removed and replaced. The advice of the Certificate holder should be sought.

## 12 Durability



12.1 The durability of Kalzip sheets will depend upon the coating material, the immediate environment, aspect faced and use. Colour changes will be slight and uniform on any one elevation.

12.2 When used in the context of this Certificate, uncoated aluminium Kalzip sheets will have the minimum service life given in section 12.9.

12.3 Maintenance painting may be necessary to restore the appearance of coated sheets or to extend their design life, and should be considered at the intervals given in Table 8.

12.4 For coated Kalzip sheets, if the building has an exposed eaves detail and is in an aggressive environment, or if there are corrosive conditions inside, a more durable specification of the reverse-side coating should be used. Details can be obtained from the Certificate holder.

12.5 A planned maintenance cycle (see section 11) should be introduced if an extended design life is required. The manufacturer can recommend a suitable system for maintenance painting. In addition, specific requirements apply to stucco-finished uncoated aluminium (see section 12.8).

12.6 Stucco-finished uncoated aluminium sheets must not come into contact with the materials listed below. Where problems arising from incompatibility are likely to occur, barriers (eg paints, bimetallic separation tapes or pads) appropriate to the materials and environment should be incorporated:

*in any conditions*

- ungalvanized mild steel
- timber treated with fire retardants
- brass
- mortar
- copper and its alloys
- alkali-bearing materials

*in damp conditions*

- timber preserved with copper or fluoride compounds
- other metals (ie bimetallic contact)

*in marine environments*

- lead
- stainless steel

*in industrial environments*

- lead

12.7 Drainage from copper onto the sheets is to be avoided but drainage from the sheets onto copper is acceptable.

12.8 Under normal exposure conditions aluminium sheets do not need painting for corrosion resistance but, if desired, can be painted using conventional techniques for the materials.

12.9 Roofing constructed with uncoated stucco finished aluminium sheet will have a minimum service life of 40 years in rural and suburban environments and 25 years in more aggressive areas, eg severe industrial or marine environments.

*Table 8 Minimum service life (ie that when first maintenance painting is considered) (years)*

Sheet material	Environment	
	Rural or suburban	Industrial or marine
Uncoated aluminium alloy (eg stucco embossed)	40	25
AluPlusZinc-coated aluminium alloy <sup>(1)</sup>	10	10
Polyester-coated aluminium alloy <sup>(2)</sup>	15	10
PVDF-coated aluminium alloy <sup>(2)</sup>	20	15
ARS-coated aluminium alloy <sup>(2)</sup>	20	15

(1) Full details are given in BBA Certificate 08/4571.

(2) Full details are given in BBA Certificate 93/2922.

## Installation

### 13 General

Installation is carried out by experienced roofing contractors trained and approved by the Certificate holder.

### 14 Procedure

14.1 Decking sheets are placed in position with all joints lapped, stitched and sealed (where necessary) and fixed to the roof rafters. Solid filler blocks are located in the decking profile at details such as eaves, hips and ridges. Side and end laps are sealed (where necessary) with synthetic rubber sealing strip and stitched with aluminium or stainless steel blind-sealed or bulbrite rivets or stainless steel stitching screws.

14.2 Swarf or debris is removed from the decking before being covered by the vapour control layer sheets, which are laid in the same direction as the decking sheets and made continuous by lapping all joints by a minimum 50 mm and sealing with tape. The VCL sheets should be continuous over ridges/hips and sealed to penetrations/abutments.

14.3 Where required and dependent on specification, the top-hat profile sub-purlin is installed over and fixed direct to the decking sheet.

14.4 Clip positions are marked out and the ST clips and thermal barrier pads or E clips (and spacers where specified) are fixed direct to the decking sheets or to the top hat profile sub-purlin support.

14.5 The mineral wool blanket is placed and eased over the ST clips or E clips.

14.6 The Kalzip sheets are installed and joints secured using the powered 'zipper' tool supplied by the Certificate holder.

14.7 When splicing two sheets (see Figures 6 and 7), 6.3 mm diameter stainless steel screws or aluminium rivets should be used in conjunction with the sealant, or a continuously welded joint can be used. For roof pitches lower than 3°, a continuously welded joint is essential.

14.8 On completing the installation of the sheets, the various ridge, perimeter and eaves fittings are fixed. To assist in the installation of the verge flashings, the tolerance gable profile can be fitted by locking over the gable end clips and gable end channel. The flashing can then be fixed to the top inside flange, which does not penetrate the roof build-up, allowing it to move independently of the Kalzip standing seam sheets.

14.9 Typical construction details are shown in Figures 4 to 8.

Figure 4 Typical eaves, ridge and verge details

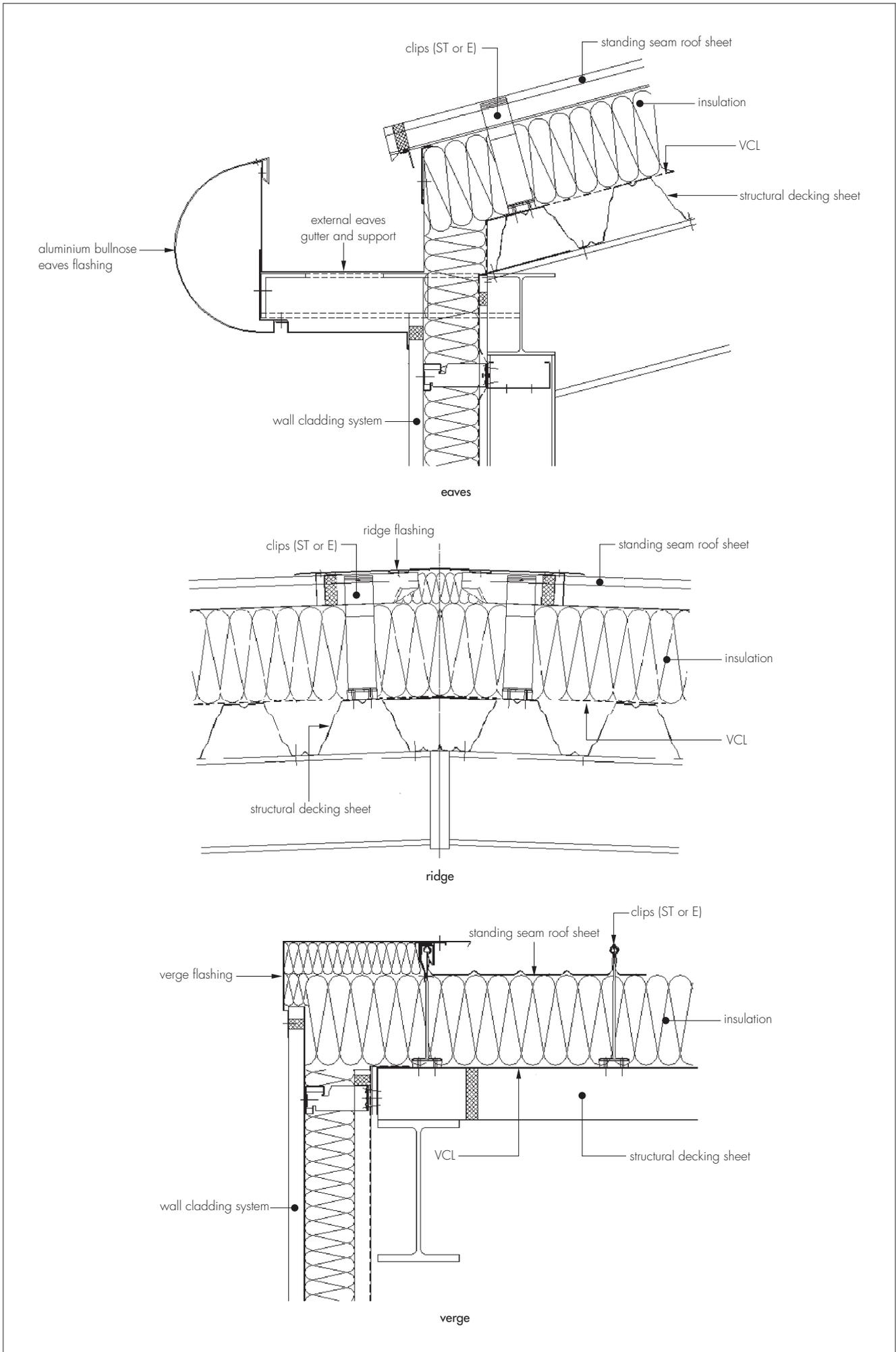


Figure 5 Verge (gable components)

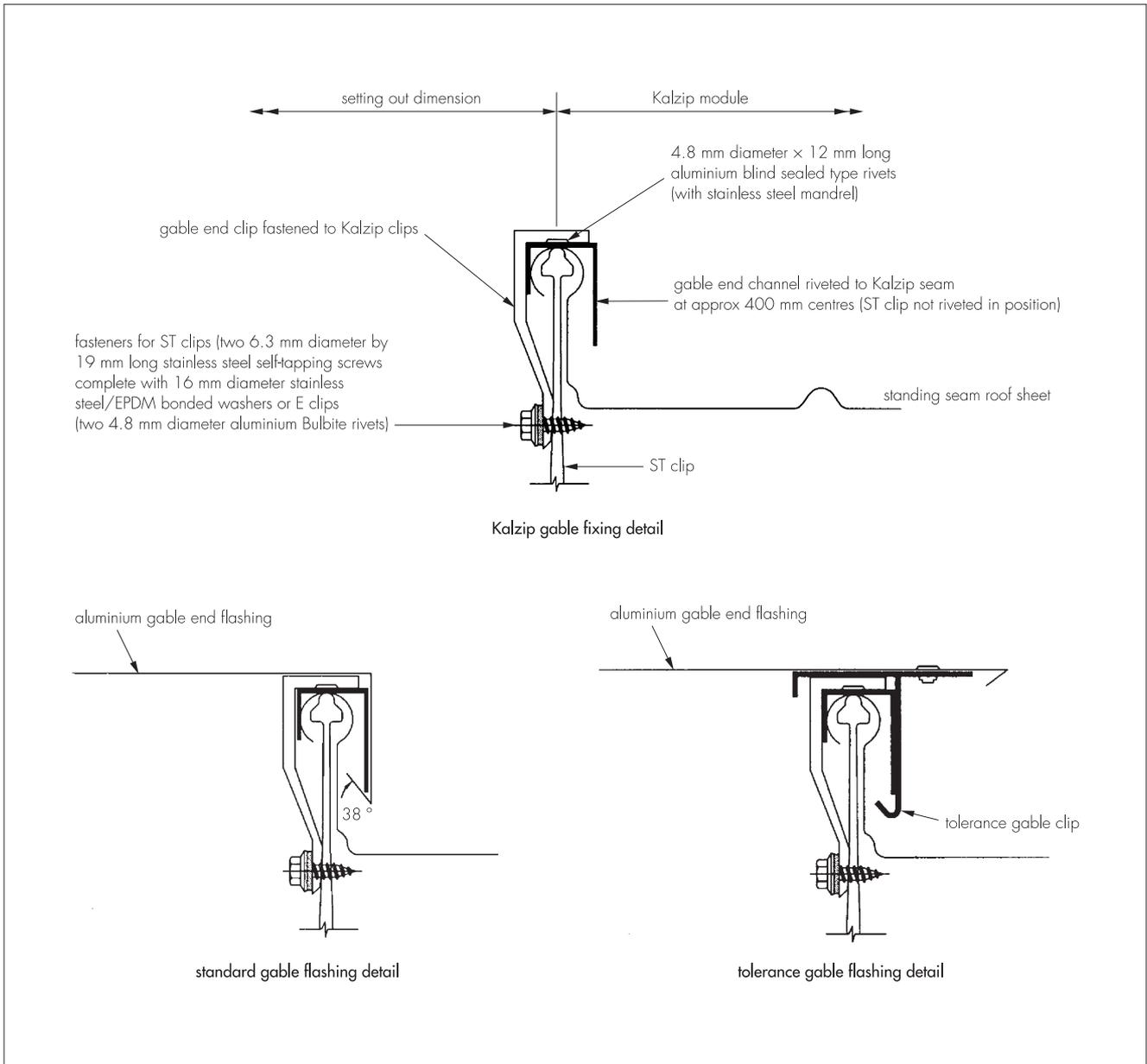


Figure 6 Welded lap joint

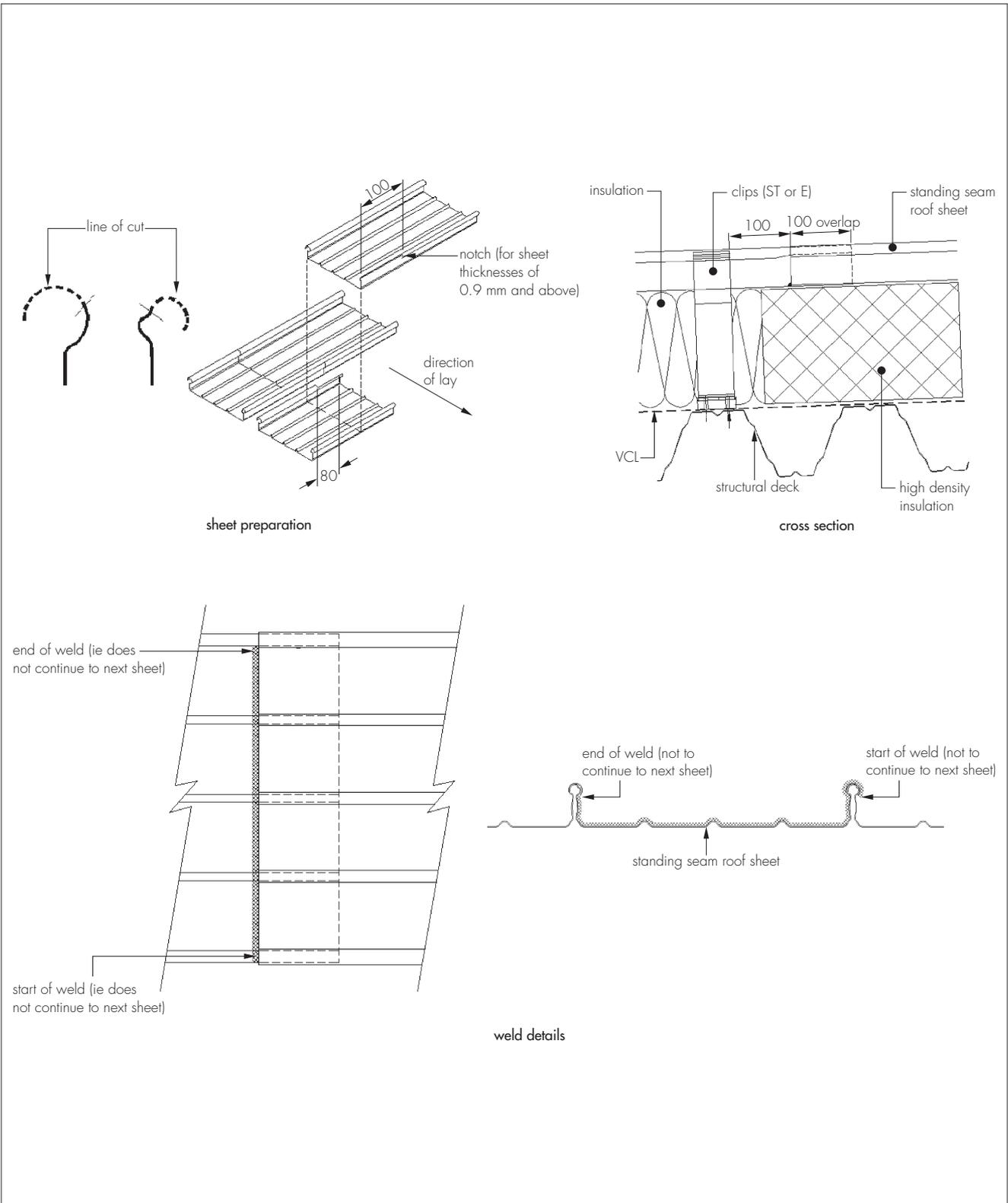


Figure 7 Lap joint using sealant and rivets (not to be used on roof pitches of less than 4°)

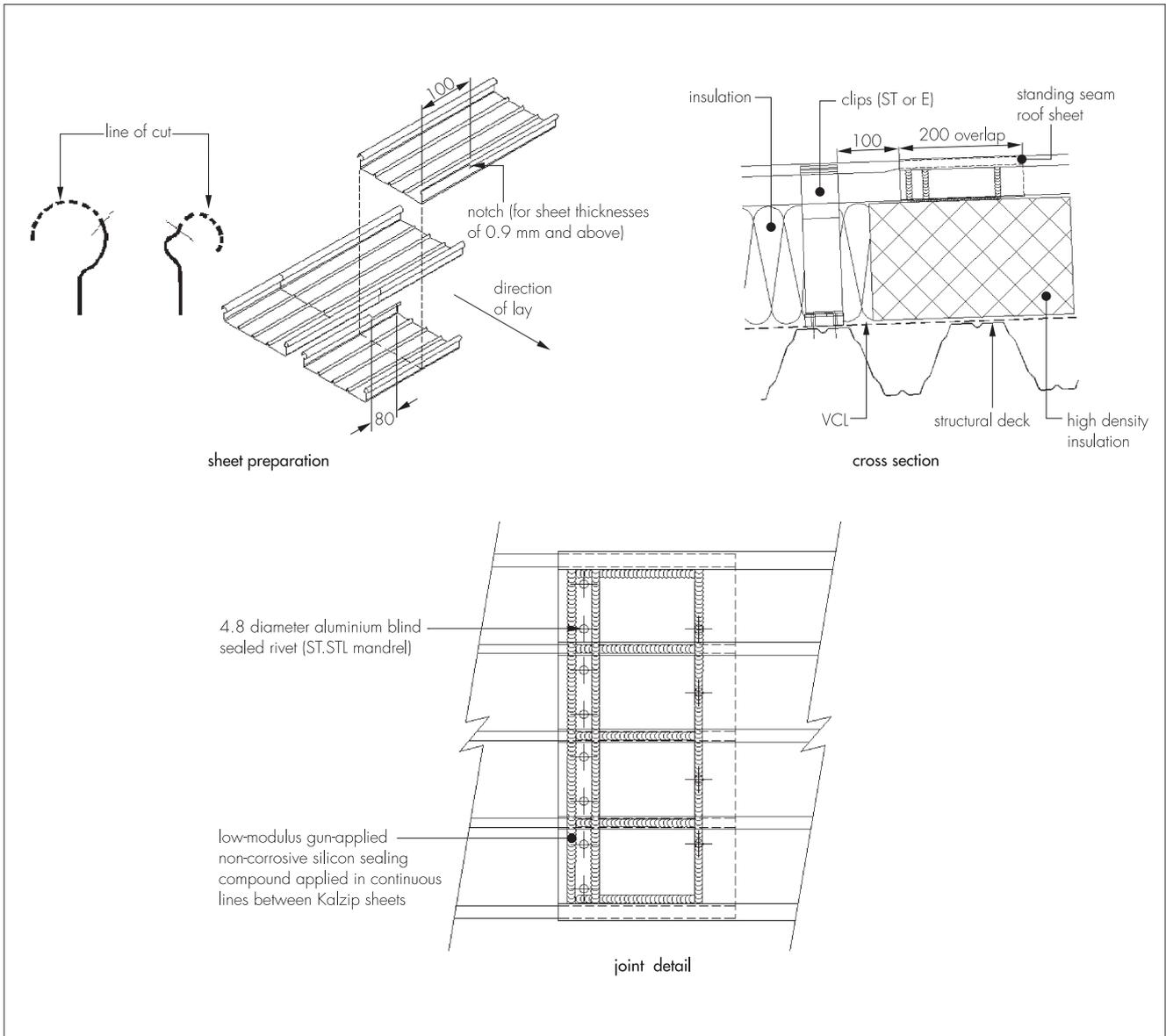
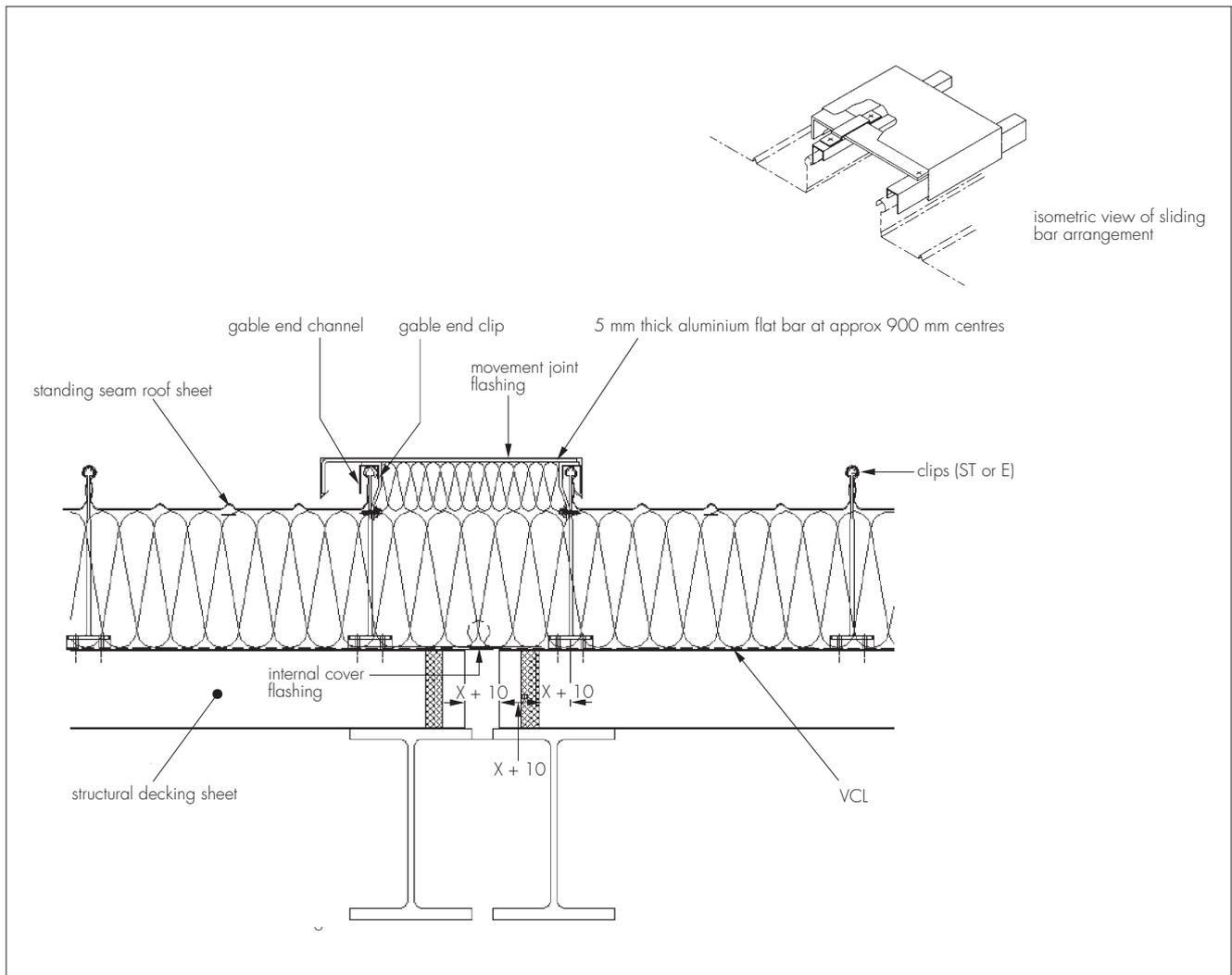


Figure 8 Building and movement joint



## Technical Investigations

### 15 Tests

Tests were carried out on the system to establish:

- resistance to dead and imposed (snow) loading
- behaviour of fixings and profile under static and cyclic loading
- behaviour under concentrated loads.
- resistance to wind loading
- resistance to impact

### 16 Investigations

16.1 The manufacturing process was examined, including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

16.2 An assessment was made of:

- fire resistance
- practicability of installation
- condensation risk and thermal transmittance
- weathertightness of fixed cladding and details
- acoustic performance of deck roof system.

16.3 Existing information, relating to the durability of the system, performance in fire and compatibility of materials in contact, was examined.

16.4 A visit was made to a site to assess the practicability of installation.

## Bibliography

- BS 476-3 : 2004 *Fire tests on building materials and structures — Classification and method of test for external fire exposure to roofs*
- BS 476-4 : 1970 *Fire tests on building materials and structures — Non-combustibility test for materials*
- BS 5250 : 2002 *Code of practice for control of condensation in buildings*
- BS 5925 : 1991 *Code of practice for ventilation principles and designing for natural ventilation*
- BS 6229 : 2003 *Flat roofs with continuously supported coverings — Code of practice*
- BS 6399-2 : 1995 *Loading for buildings — Code of practice for wind loads*
- BS 6399-3 : 1988 *Loading for buildings — Code of practice for imposed roof loads*
- BS EN 485-1 : 2008 *Aluminium and aluminium alloys — Sheet, strip and plate — Technical conditions for inspection and delivery*
- BS EN 1396 : 2007 *Aluminium and aluminium alloys — Coil coated sheet and strip for general applications — Specifications*
- BS EN 10346 : 2009 *Continuously hot-dip coated steel flat products — Technical delivery conditions*
- BS EN 755-1 : 2008 *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Technical conditions for inspection and delivery*
- BS EN 13162 : 2008 *Thermal insulation products for buildings — Factory made mineral wool (MW) products — Specification*
- BS EN ISO 1182 : 2002 *Plastics — Reaction to fire tests for building products — Non-combustibility test*
- BS EN 1991-1-3 : 2003 *Eurocode 1 : Actions on structures — General actions — Snow loads*
- BS EN 1991-1-4 : 2005 *Eurocode 1 : Actions on structures — General actions — Wind actions*
- BS EN ISO 10211 : 2007 *Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations*
- BS EN ISO 13788 : 2002 *Hygrothermal performance of building components and building elements — Internal surface temperature to avoid critical surface humidity and interstitial condensation — Calculation methods*

## 17 Conditions

17.1 This Certificate:

- relates only to the product/system that is named and described on the front page
- is granted only to the company, firm or person named on the front page — no other company, firm or person may hold or claim any entitlement to this Certificate
- is valid only within the UK
- has to be read, considered and used as a whole document — it may be misleading and will be incomplete to be selective
- is copyright of the BBA
- is subject to English law.

17.2 Publications and documents referred to in this Certificate are those that the BBA deems to be relevant at the date of issue or re-issue of this Certificate and include any: Act of Parliament; Statutory Instrument; Directive; Regulation; British, European or International Standard; Code of Practice; manufacturers' instructions; or any other publication or document similar or related to the aforementioned.

17.3 This Certificate will remain valid for an unlimited period provided that the product/system and the manufacture and/or fabrication including all related and relevant processes thereof:

- are maintained at or above the levels which have been assessed and found to be satisfactory by the BBA
- continue to be checked as and when deemed appropriate by the BBA under arrangements that it will determine
- are reviewed by the BBA as and when it considers appropriate.

17.4 In granting this Certificate, the BBA is not responsible for:

- the presence or absence of any patent, intellectual property or similar rights subsisting in the product/system or any other product/system
- the right of the Certificate holder to manufacture, supply, install, maintain or market the product/system
- individual installations of the product/system, including the nature, design, methods and workmanship of or related to the installation
- the actual works in which the product/system is installed, used and maintained, including the nature, design, methods and workmanship of such works.

17.5 Any information relating to the manufacture, supply, installation, use and maintenance of this product/system which is contained or referred to in this Certificate is the minimum required to be met when the product/system is manufactured, supplied, installed, used and maintained. It does not purport in any way to restate the requirements of the Health & Safety at Work etc Act 1974, or of any other statutory, common law or other duty which may exist at the date of this Certificate; nor is conformity with such information to be taken as satisfying the requirements of the 1974 Act or of any statutory, common law or other duty of care. In granting this Certificate, the BBA does not accept responsibility to any person or body for any loss or damage, including personal injury, arising as a direct or indirect result of the manufacture, supply, installation, use and maintenance of this product/system.