10 Designing for optimum fire performance

10.1 Introduction

This section consolidates the information given in the previous chapters into a single chapter covering 'good practice' in the design of insulated panel systems. Designers should also refer to the section 11 which provides guidance and recommendations relating to site installation, fixing and design detailing.

The following pages describe the way design and installation can affect the performance of insulated panels in the developing stages of a fire. The principle is to maintain structural integrity and prevent significant contribution from the building envelope during the early stages of a fire so that escape can be facilitated, damage to property minimised and the fire services can effectively treat the incident on arrival.

The fire resistance of insulated panel walls is considered separately in section 12.

10.2 Background

Insulated panels have been used to form the external roofs and walls of buildings for over 35 years. Historically their use was predominantly in the industrial and distribution construction sectors with some early use in housing. Insulated Panels can now be found in most areas of construction due to the primary regulatory requirements for thermal and energy efficiency and the practical issues of ease and speed of construction.

The predominant insulating material used in panels manufactured for the external envelope is rigid urethane, due to its superior thermal insulating properties. High density mineral fibre has been used more recently for certain applications and these products command about 10% of the market. Very little polystyrene, phenolic foam, or cellular glass have been used as the insulating core.

It is not normal for external envelope panels to be involved at the early stages of a fire. Occasionally they have become involved as the fire has become fully developed by which time the property is a potential loss. The security of panels and the protection afforded by the design and the use of metal facings is fully discussed in sections 8 and 9. The net result is that correctly specified and installed insulated panels used for the external envelope present little risk to the building occupants or contents.

Large scale tests have shown that protected joints, secure fixings and proper detailing of vulnerable areas such as penetrations and potential voids can further improve the reaction to fire performance of external insulated panels systems.

10.3 Regulations affecting design

Statutory requirements are described in Section 2. The following summarises the compliance of roof and wall insulated panels.

10.3.1. Surface spread of flame and prevention of penetration

Metal faced panels with the standard protective coatings – PVC plastisol [normally 200 microns] or PVDF [25-30 microns] generally satisfy the standard BS 476 tests (parts 3, 6 and 7) giving a Class 0 surface rating and a Class AA rating for roofs. These ratings are achieved irrespective of the choice of core material and in regulatory terms panels are deemed to satisfy the requirements.

Under the new European Tests, surface spread of flame and penetration are assessed by a combined reaction to fire test that results in a Euroclass designation. The class level is influenced by the type of core material and joint design. Insulated panels with mineral fibre cores generally obtain Class B and urethanes Class B, C or D dependent upon the specific formulation and design.

Roof panels are in addition subject to a separate External Fire Performance test (EFP). Insulated panels obtain the highest classification in accordance with the EFP test criteria.

10.3.2. Fire resistance

Fire resistance requirements apply only in certain circumstances to external wall panels. The requirements are detailed in sections 3, and 4 and cover integrity and insulation. Some urethane panels achieve 15 minutes insulation and in excess of 120 minutes integrity. Panels with mineral fibre cores can achieve insulation and integrity for times in excess of 120 minutes dependent upon the panel design and density of core material. Some of these panels can satisfy the requirements for internal compartmentation.

10.4 Assessment of fire risk

Observation of large-scale tests and real fires show that all types of insulated panel delaminate in a fire. Where the facings are securely fixed to the structural framework as in the case of external wall and roof panels, delamination is restricted and the facings remain in place [see 11.4 and Figure 16].

The core of current panels with factory engineered joint designs is protected from direct flame impingement and only gradually contributes to the fire. The core will not continue to contribute after the fire is controlled or the surface is cooled – by sprinklers or the actions of the Fire Service etc.

10.5 Panel selection

The various building regulations set out minimum standards for the fire performance of external cladding systems. However, it is recommended that the selection of insulated panels be based upon the recommendations given in Section 9, table 13. Whilst these recommendations are generally in excess of current building regulations requirements they represent industry best practice and will assist in reducing the risk to building occupants and fire fighters.

10.6 Structure and fixings

Insulated panels are factory engineered products designed for a long and durable life. The composite nature of the construction ensures good strength sufficient to withstand the forces of the elements, wind, snow loadings etc and movements of a typically lightweight framework structure. Panels designed for the external cladding of the envelope can sustain substantial movements of the supporting frame without compromising the weather tightness or joint integrity.

Throughout the 1990s there was a continual development of the panel-to-panel joint detailing together with improvements in fixing technology. Studies of panels involved in total loss fires have shown that the current standard fixings enable the structural integrity of the panels to be maintained until there is deformation and collapse of the supporting steelwork.

10.6.1. Structural steelwork and framework tolerances

Tolerances for structural steelwork are defined in BS 5950: The structural use of steelwork in building: Parts 2 & 7 1992. However no tolerances are defined for the position of purlins and cladding rails relative to the main frame and in particular no mention is made of the position of the surface of the purlins and rails to which the cladding will be fixed.

Excessive variation in this fixing plane can cause assembly problems for the cladding contractor and can affect the panel strength, weather tightness, fire performance, and the appearance of the finished building.

The guidance tolerance for insulated panels is based on BS 5950. The fixing surface of each purlin/rail should be within L/600 of the surface of the adjacent purlins/rails where L is the spacing between purlins. This equates to 3mm for a 1.8m rail spacing. The maximum variation from the theoretical cladding plane should be 20mm.

10 Designing for optimum fire performance

The joint design of typical insulated panel systems provides a degree of flexibility to accommodate variations in the supporting steel frame. However as with all cladding systems, tightening up the tolerances and alignment of the structural steelwork, purlins etc can significantly improve the joint efficiency in terms of air tightness and at the same time facilitate a tight joint that will give optimum fire performance.

Similarly junction details at the cill, head, corner etc should be able to accommodate the variation in the fixing planes. Typical details are shown in section 11.

> Structural tolerances should be kept to within the guidance tolerance for insulated panels to ensure tight fitting joints and optimum fire performance of the panel system.

10.6.2. Joint design and installation

Standard joint designs are described in section 11. The fire performance of well designed panel-to-panel joints has been proved in real fires and large-scale fire tests. Therefore when a suitable system has been specified there are no on-site measures or specific additional techniques necessary to improve the fire performance.

10.7 Detailing

The following good practice guidelines should be considered in conjunction with the mandatory requirements [1] for airtightness levels of $10m^3/m^2/h$ required from April 2002 and reducing to $5m^3/m^2/h$ by 2007. The techniques for design detailing and installation are common for both air tightness and optimum fire performance and cover all types of external insulated panel irrespective of the core material.

The chief principle behind good detailing is the correct use of metal closures and flashings. This is not necessarily new technology. The basic methods and recommendations for details have been employed for many years. To achieve air tightness standards and also best fire performance it is important that the detailing should be designed and carried out on site with both these factors in mind and without compromise.

10.7.1. General design points

The following procedures should be adopted to ensure optimum fire performance by ensuring that a combustible core material is not exposed to direct flame impingement.

- closures/flashings should be steel with a minimum thickness of 0.5mm and minimum girth of 50mm;
- stitching should be at a maximum of 400mm centres;
- closures should not be omitted, even if not visible behind columns etc.

Recommended standard typical details are shown in section 11 – Installation, fixing and detailing. The following details are illustrated:

- Drip detail – wall or floor
- Head detail – wall/ceiling/wall/roof
- Windows
- Doors
- Internal and external corners
- Penetrations
- Internal roof [ridge]
- Roof/wall – verge
- Roof/wall – eaves
- Roof/wall – parapet cladding
- Roof vents and penetrations
- Hot flues
- Internal valley gutter
- External soffit
- Break flashings – walls

Note: For 'scale' details and details not illustrated in section 11, reference should be made to manufacturer's detailed drawings, or advice obtained through their technical services.

10.7.2. Apertures and service penetrations

Whenever holes or apertures are cut on site through the insulated panels, all exposed cut edges should be finished off with the appropriate metal closure flashing.

11 Installation, fixing and detailing

11.1 Introduction

For the installer it is essential that the basic rules for good installation and detailing practice are followed if fire is to be prevented from bypassing the panel system at junctions, penetrations etc. There is no conflict between detailing required for energy conservation and detailing required for good fire performance as the recommended details developed for energy efficiency and air tightness also provide the optimum performance in fire.

The essential elements of fixing and detailing with fire in mind are covered in this section. Specific comments and recommended details for walls requiring fire resistance are covered separately in section 12.

11.2 Panel development

The fundamental difference between external insulated panels and panels designed specifically for internal use lies in the joint design and the method and security of fixing.

11.3 Joint design

Joints for external panels are required to be weather tight and energy efficient under 50-year wind forces and driven rain. Joints have developed under a complete re-engineering assessment and are now stronger with a substantial wrap-around of the steel together with an interlock. The addition of a return overlap nib on roof panels gives further added strength and accommodates additional sealing as required.

These developments have produced an effective panel-to-panel joint which is superior in terms of fire performance and which offers additional protection to the insulating core.

11.4 Fixings

Insulated panels used for the building envelope are in almost all cases firmly secured to the building framework using through panel fixing of both faces [Figure 14] or partial through fixing of one face in conjunction with a fully interlocking steel joint detail [Figure 15].

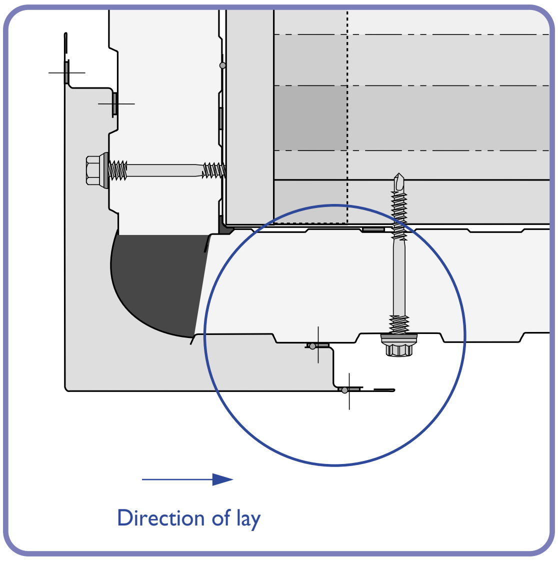

Figure 14. Illustration of through fixings

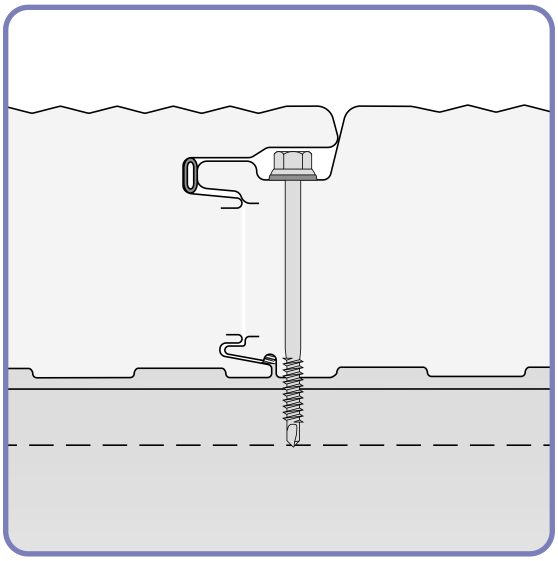

Figure 15. Illustration of secret/partial fixings

From the few fires in which insulated panels have become involved as a result of an internal fire, structural integrity has been maintained until the fire has reached fully developed proportions and the integrity of the framework has been affected.

Figure 16. The fire rated (PIR) insulated panel wall cladding remained intact in this major fire although the internal roof structure behind had totally collapsed

Steel fixings (at typical centres of 1.8m) that fulfil the required pullout strength to withstand the construction design forces for the building envelope will generally maintain the stability of the steel facings in fire without the need for change or special treatment.

Designers and specialist installers should refer to the manufacturer's recommendations for fixings according to the building application, location and the type of structural framework.

11.5 Detailing

11.5.1. Closures and flashings

Standard details usually comprise a variety of closures and flashings for application at corners, junctions, windows and doorways, penetrations etc. These play an important role in determining the fire performance of a system.

- To prevent transmission of flame and heat beyond the panel especially if there are cavities or hidden / inaccessible voids behind the cladding;
- To limit the transmission of smoke to the other side of the insulated panel;
- To protect the core and prevent direct flame impingement on the core at the ends of the panel and at penetrations or other places where the panel may have been cut;

The installer should ensure that:

- flashings are to the manufacturer's instructions in terms of material type and gauge, and girth
- flashings are installed to the recommended fixing centres
- the design of the fixings adequately accommodates differences in construction site tolerances without creating open gaps into which fire can pass.
- flashings are manufactured from steel
- seals and additional site applied insulation are to the correct specification and fire grade where required
- closures should not be omitted, even if not visible behind columns etc.

Installation, fixing and detailing

11.5.2. Recommended details

The following details illustrate the principles behind good detailing practice. They are designed to provide optimum fire performance and to take into account the improved standard required to meet the airtightness requirements of the Building Regulations: Approved Document L2: 2002 edition, which were introduced in August 2001 [1].

Where applicable the details have been designed with flexibility to take into account the difference in levels of tolerance between factory engineered insulated panels and the wider tolerance levels allowed under BS 5950 for site construction steelwork including the site installation of purlins and cladding rails.

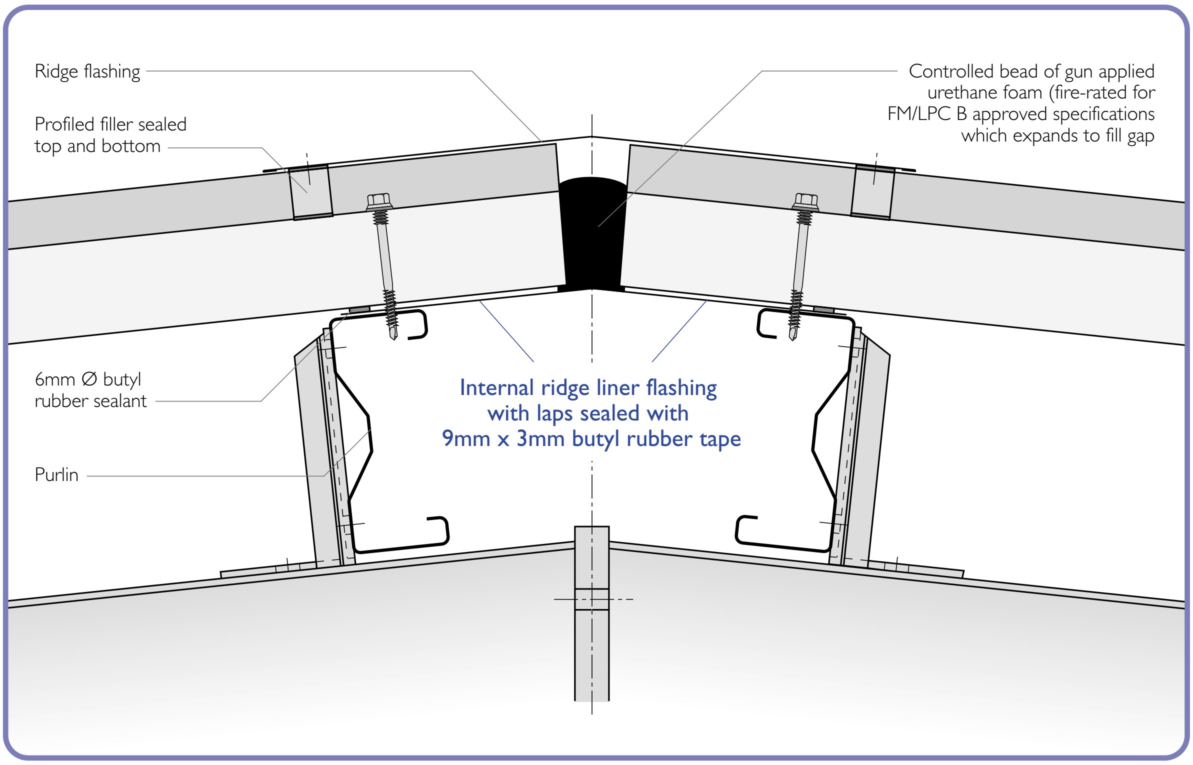

Figure 17. Standard ridge

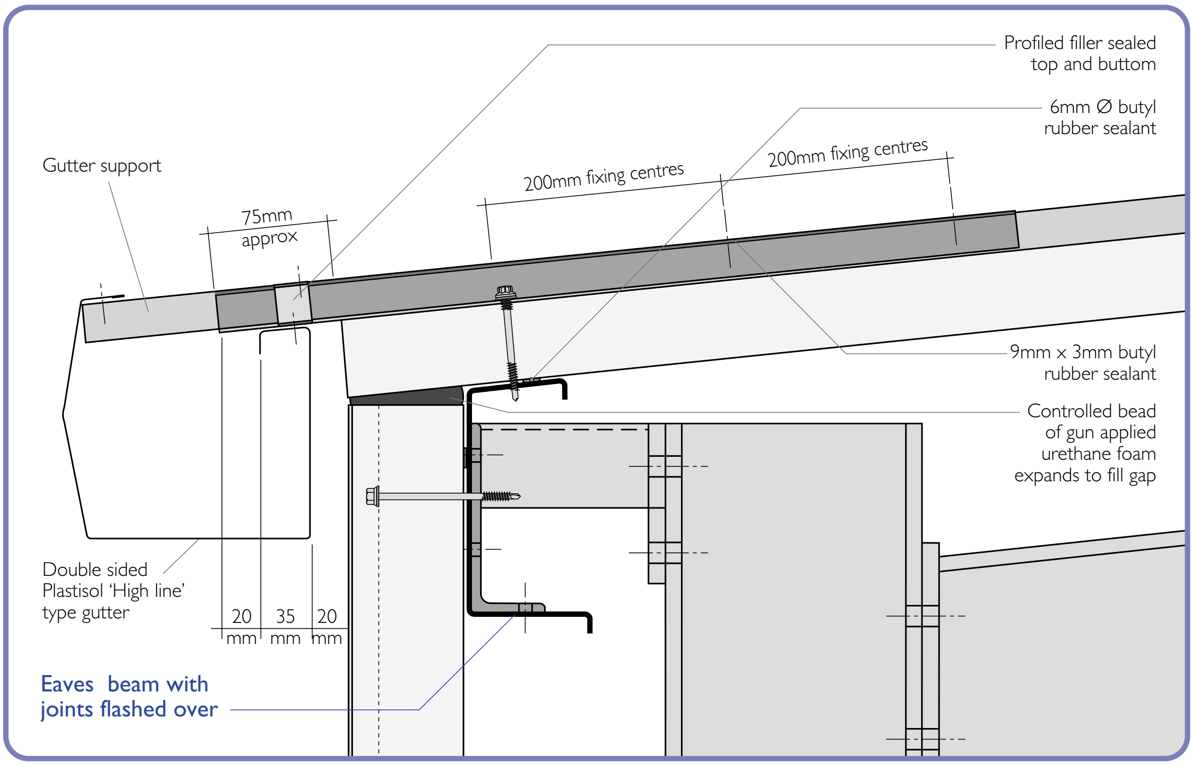

Figure 18. Eaves – external gutter

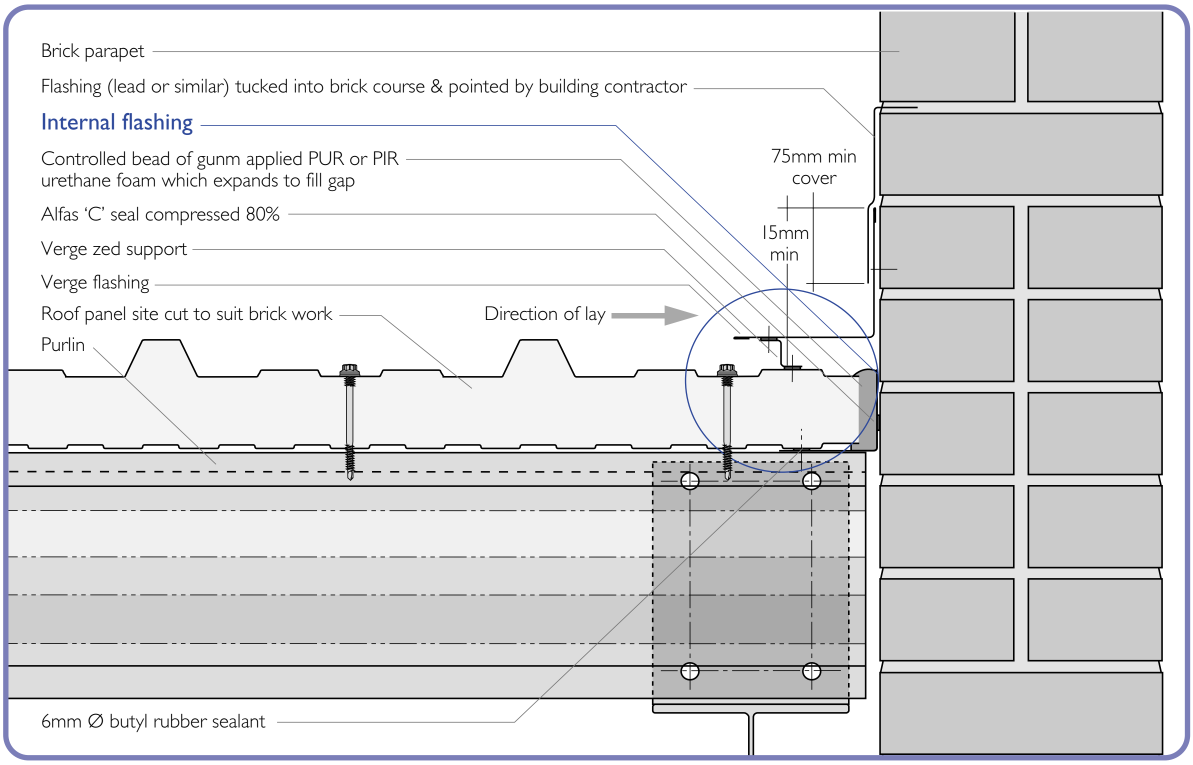

Figure 19. Verge – brick parapet

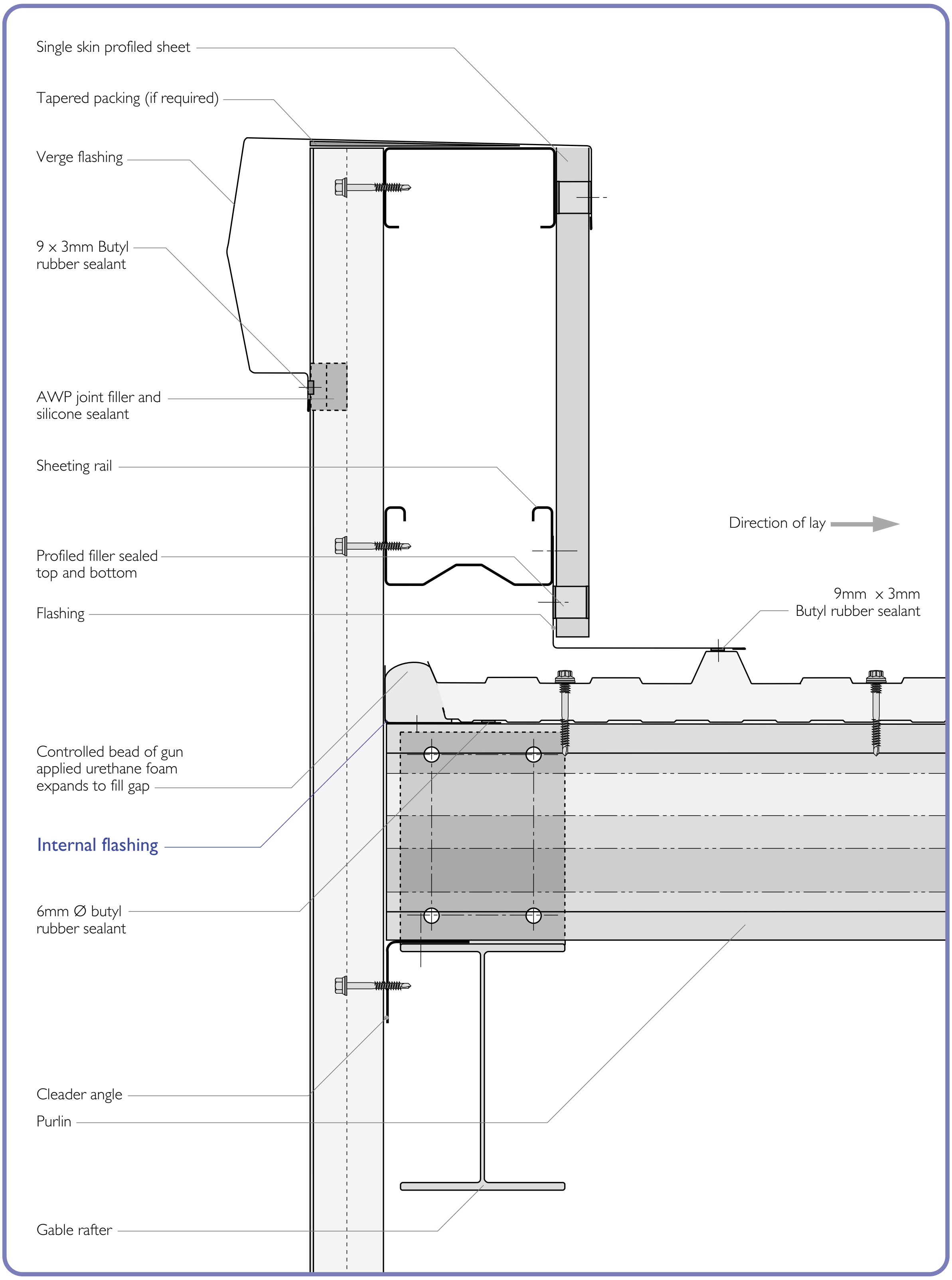

Figure 20. Verge – parapet cladding

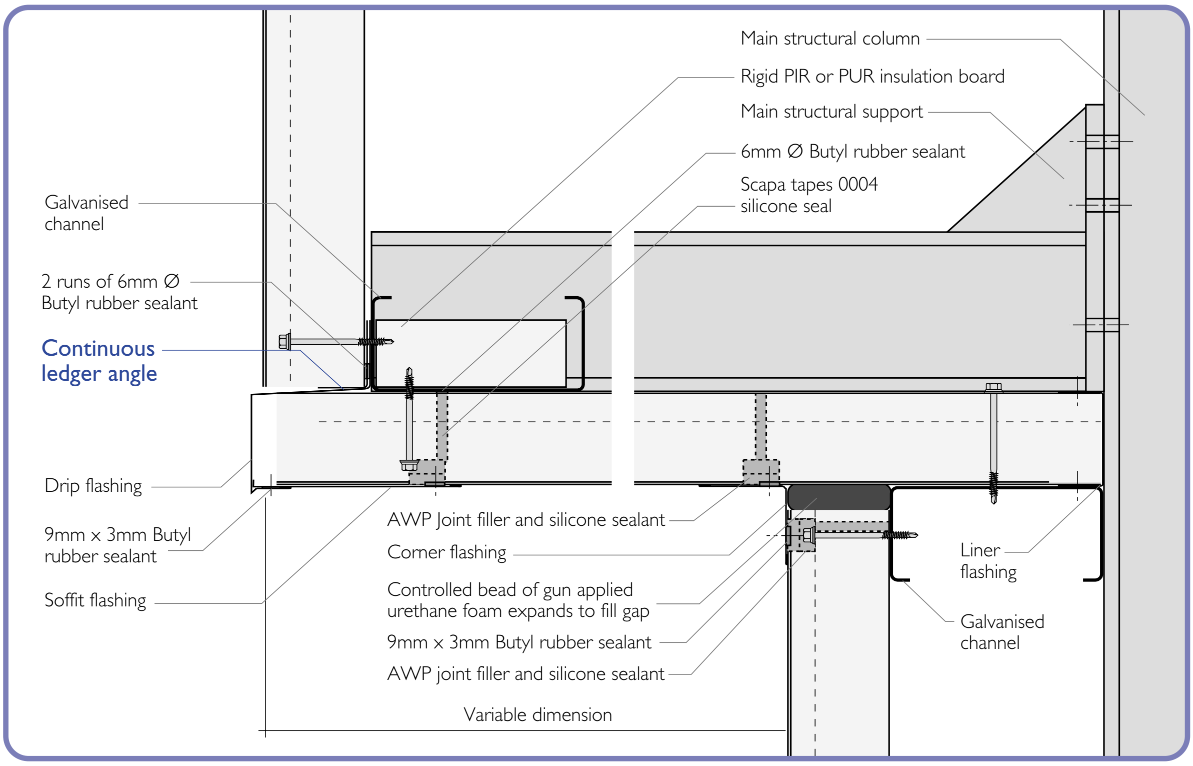

Figure 21. Soffit laid vertically

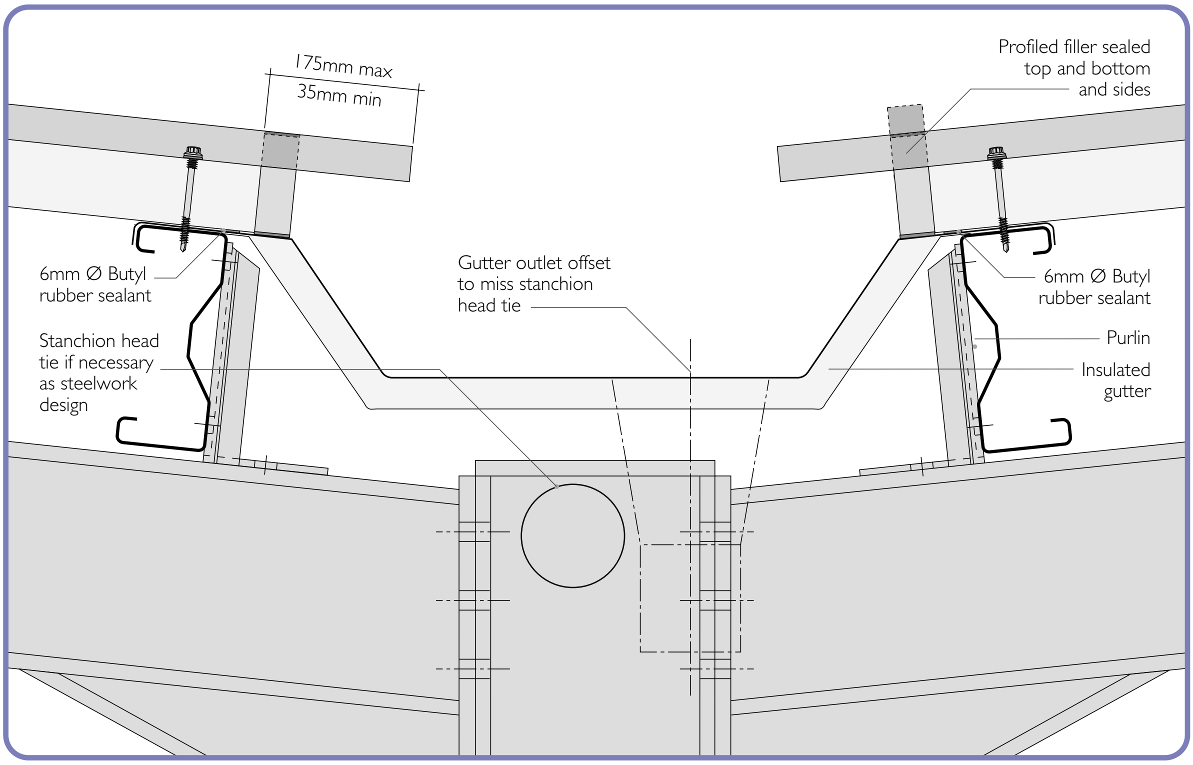

Figure 22. Valley

Installation, fixing and detailing

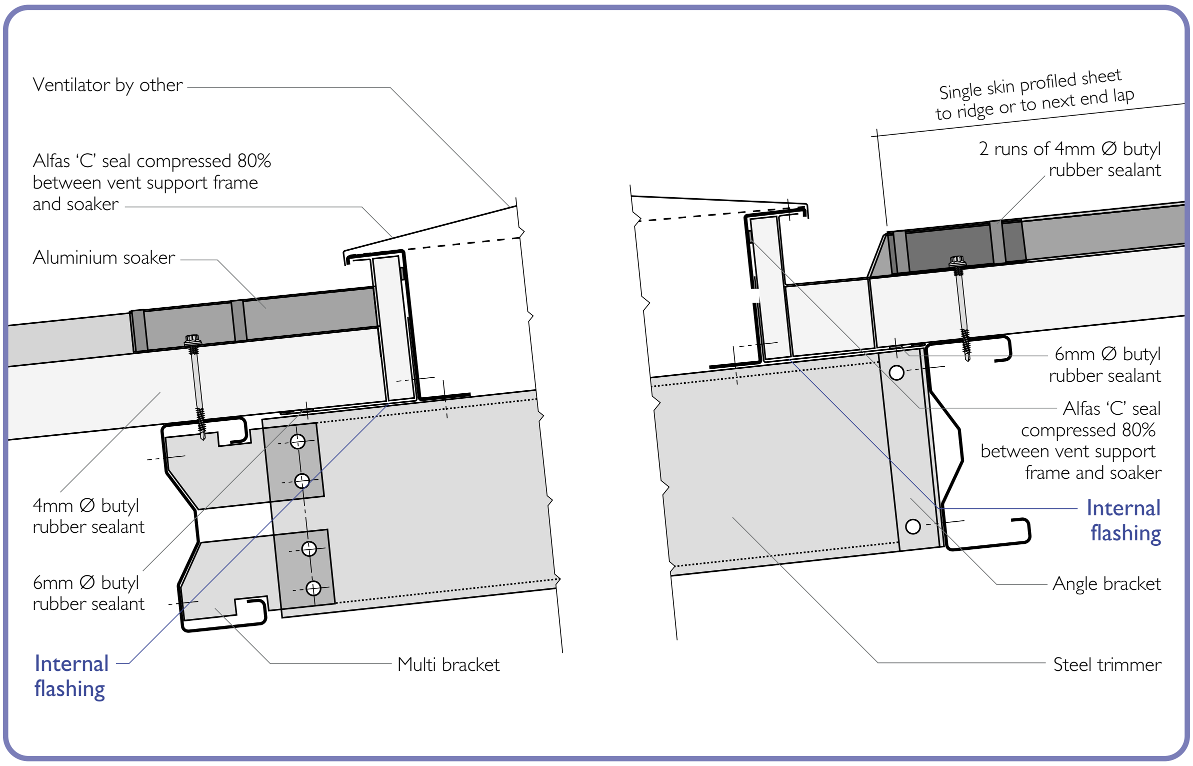

Figure 23. Roof ventilator

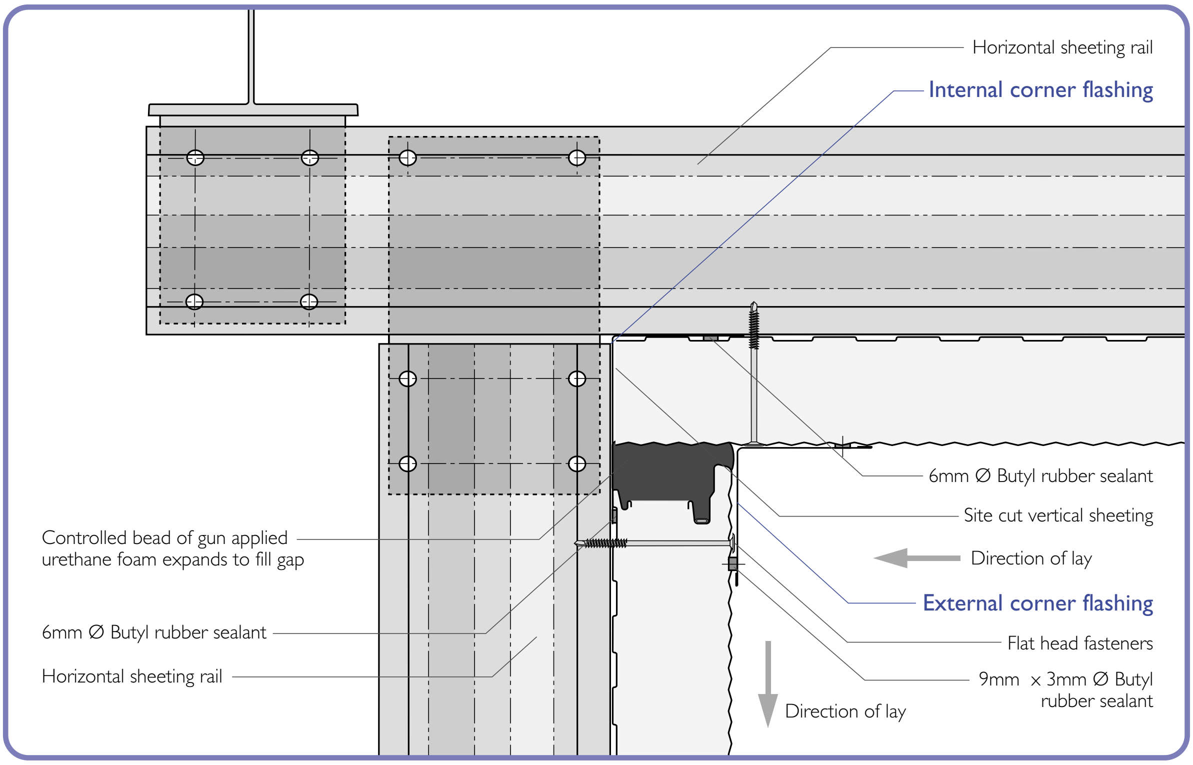

Figure 24. Internal corner

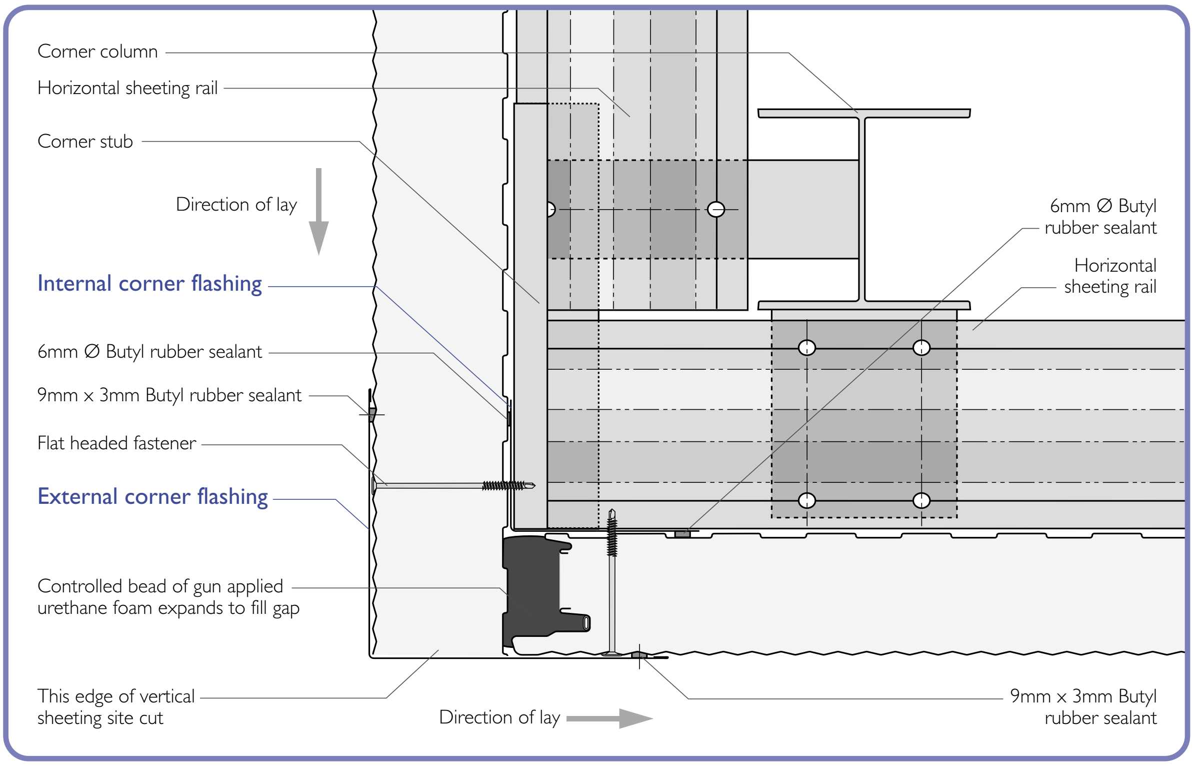

Figure 25. External corner

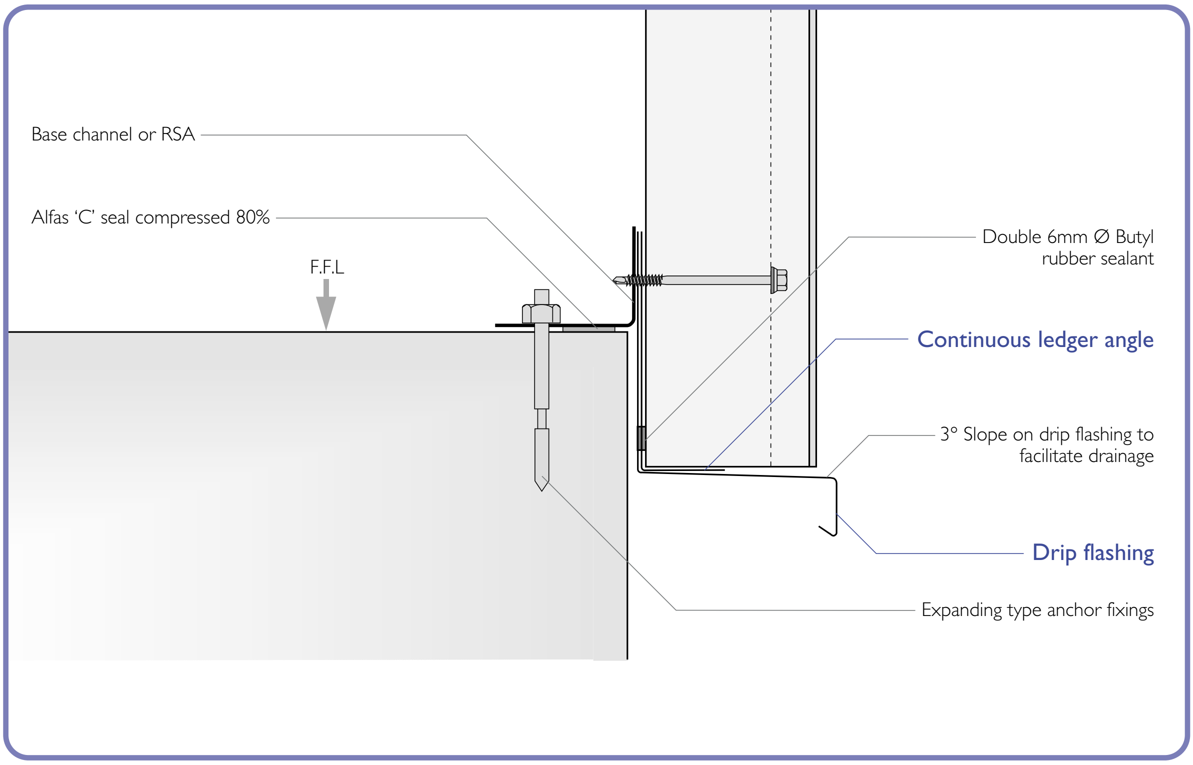

Figure 26. Drip – floor level

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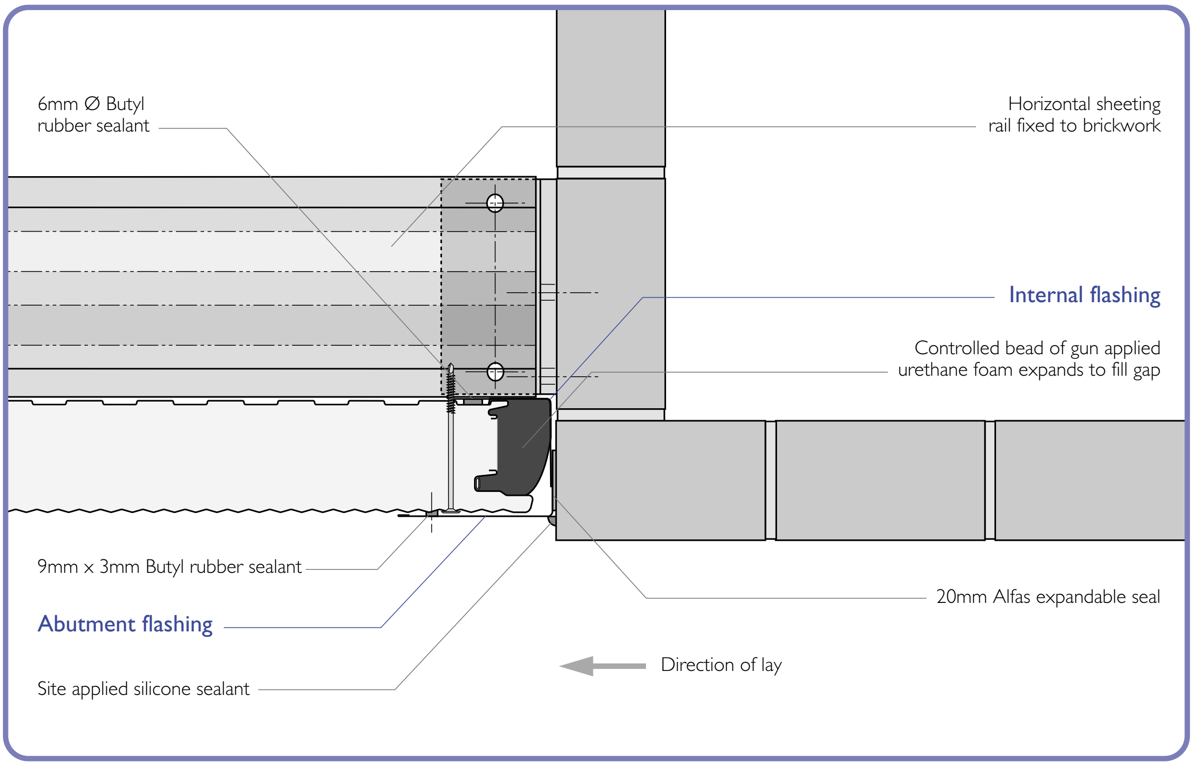

Figure 27. Abutment – brickwork

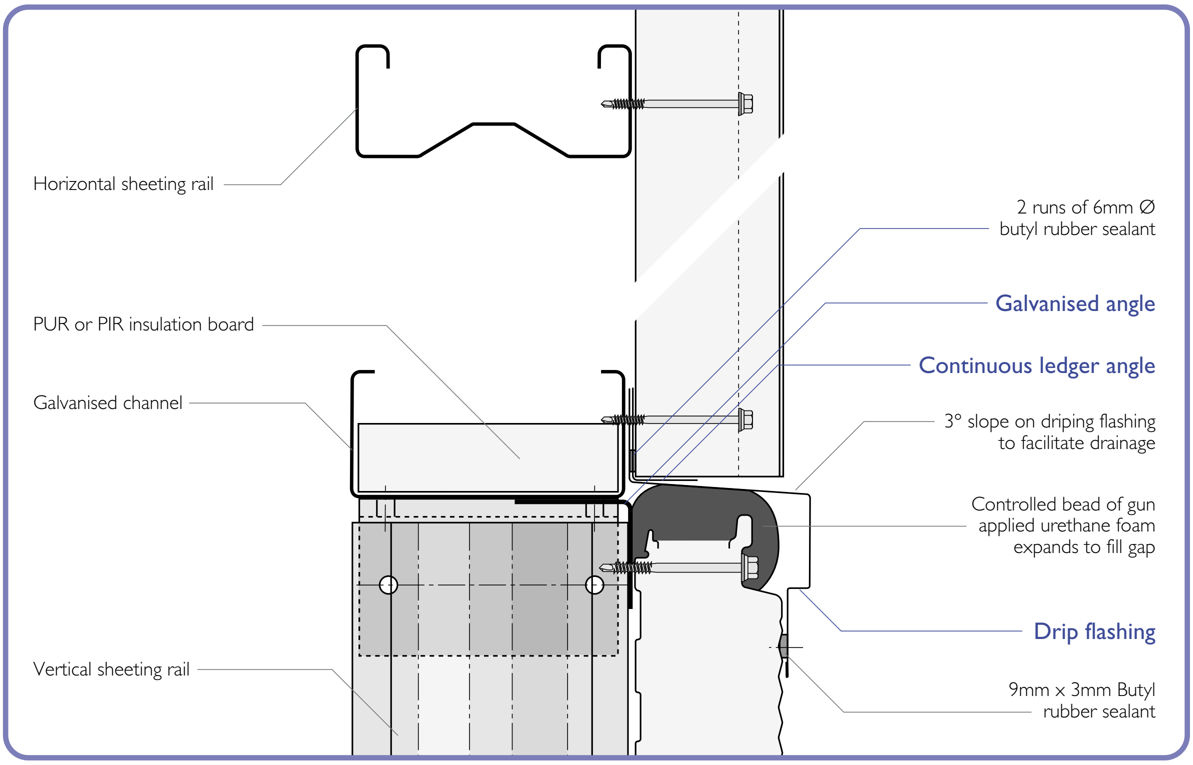

Figure 28. Stack joint

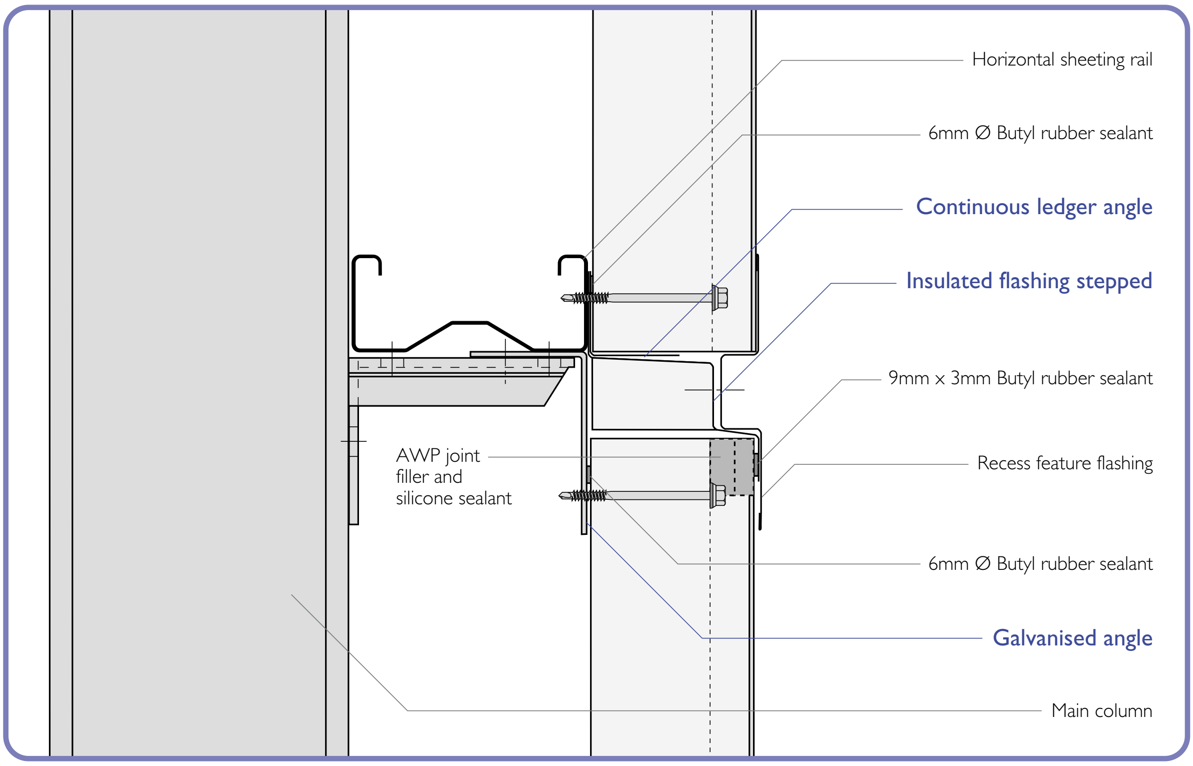

Figure 29. Panel break

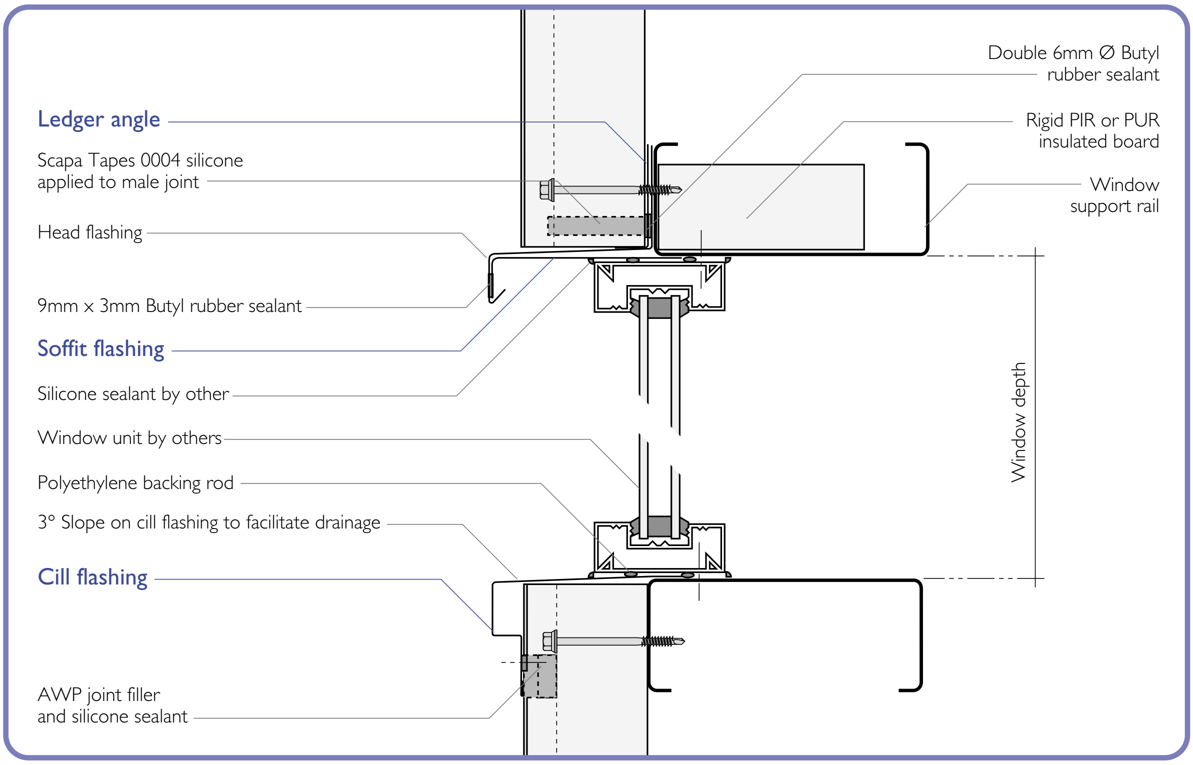

Figure 30. Window – head and cill

Installation, fixing and detailing

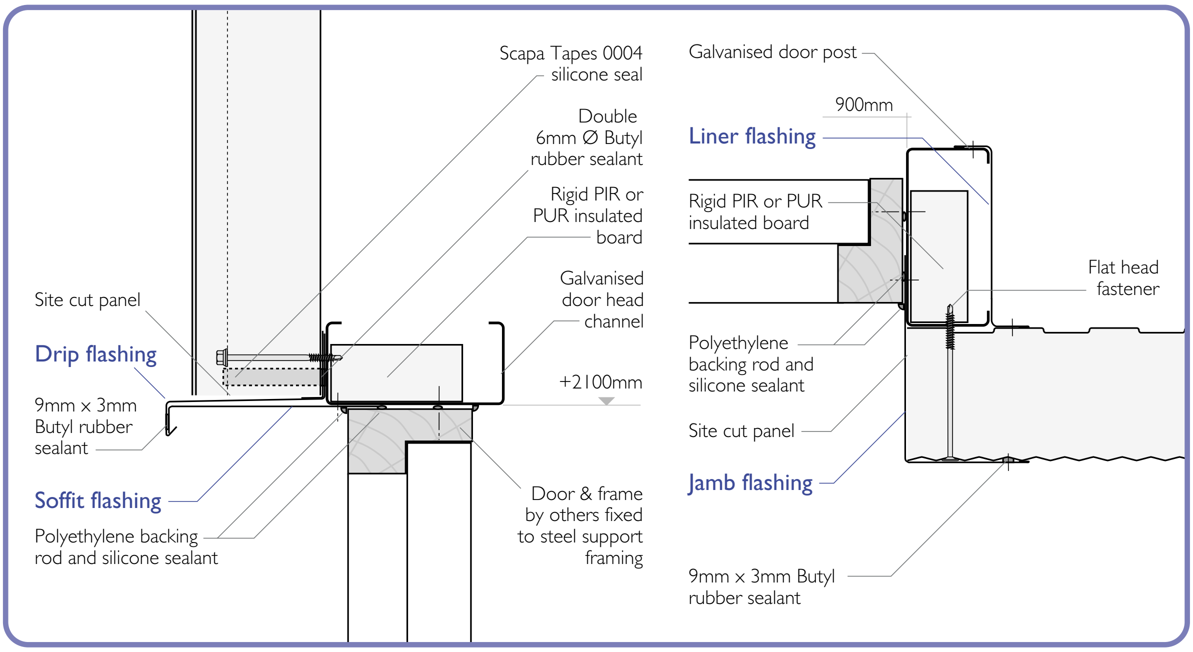

Figure 31. Door – head and jamb

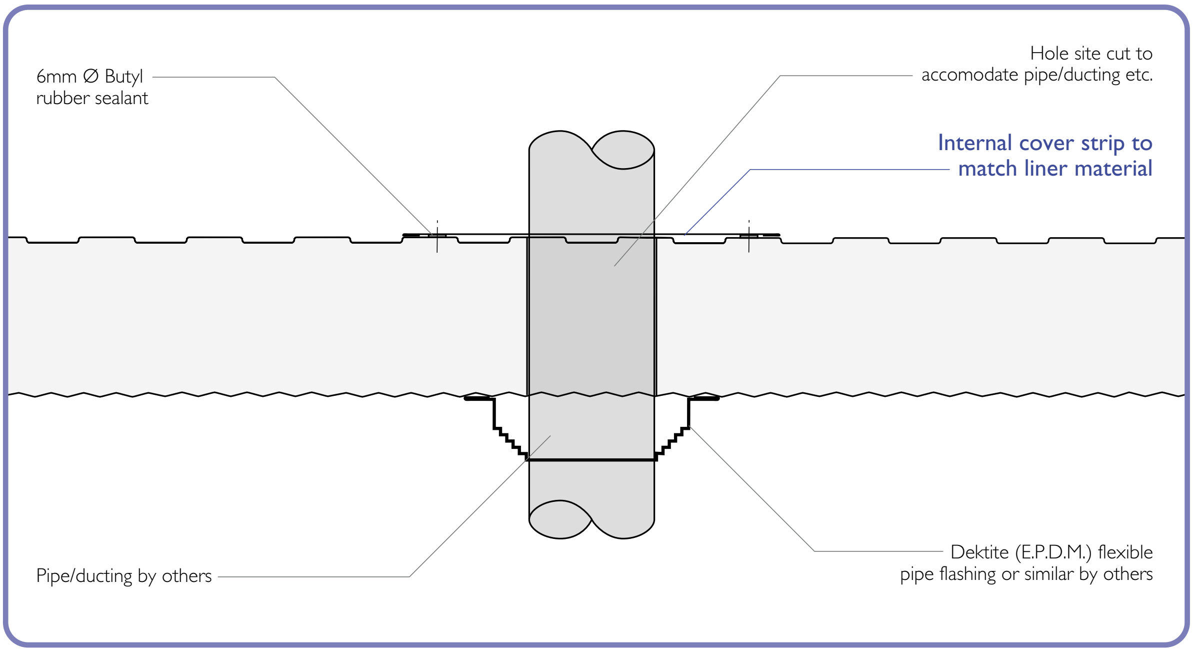

Figure 32. Wall penetration

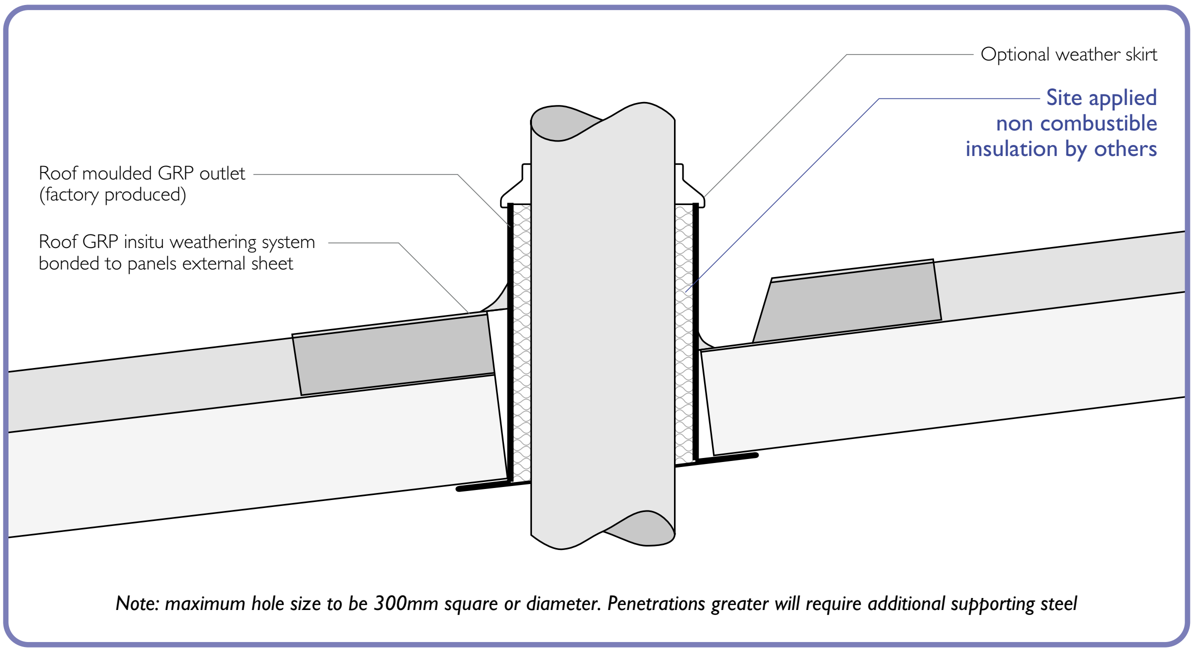

Figure 33. Hot flue – roof

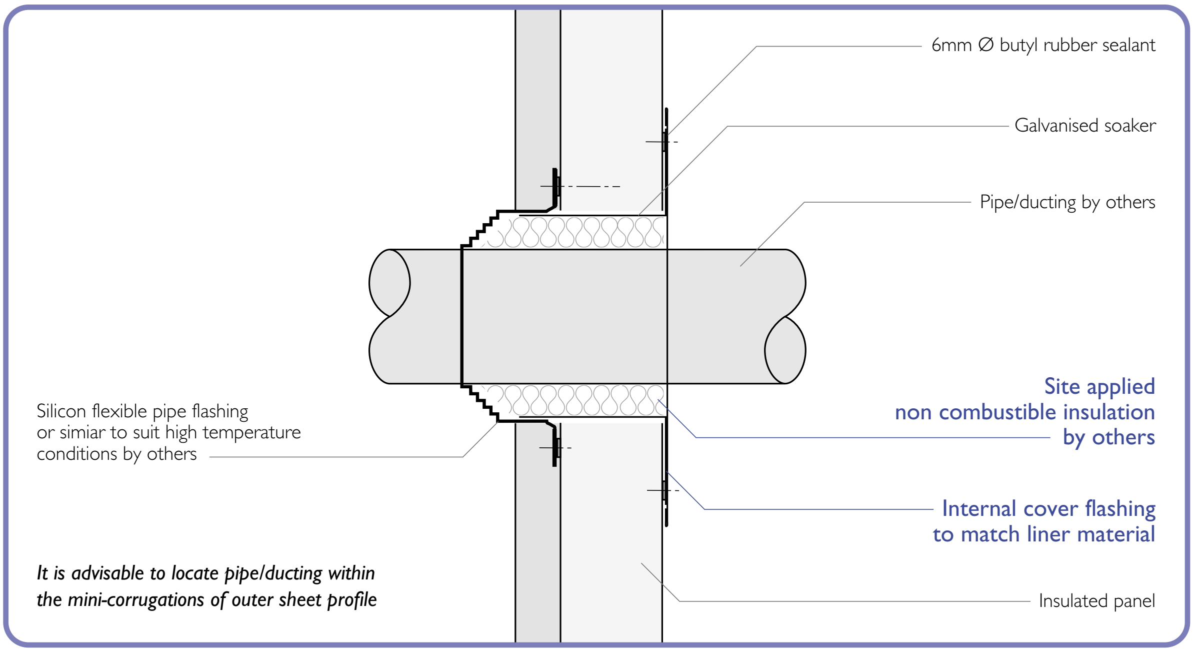

Figure 34. Hot flue – wall

For scale drawings and other details see manufacturer's detailed drawings or contact their technical services departments.

Installation, fixing and detailing

11.5.3. Apertures and service penetrations

Whenever panels are cut in-situ to create holes or apertures, the exposed cut edges should be finished off with the appropriate metal closure flashing to protect the core material from direct exposure to flames.

If the system is also required to be fire resisting the method of sealing the aperture around the penetrating services should be shown by test to satisfy the integrity and insulation criteria for the required fire resistance period.

11.5.4. Seals

Foam strip seals have been used as weather and air seals in conjunction with insulated panels for over 15 years.

With the introduction of a requirement for air tightness levels in the amendment to the Building Regulations – Approved Document L2: 2002 edition, increasing use is being made of polyurethane structural foam for the bulk filling of irregular voids and gaps between adjacent elements.

These seals are available in standard form and in flame retardant versions. It must be ensured that strip seals and infill foams do not degrade the fire performance of systems required to be fire resisting or which comply with LPC or FM standards.

12 Fire resisting construction

12.1 Introduction

For certain applications, external walls are required to provide a period of Fire Resistance – see Sections 3 to 6.

There is normally no requirement for roofs to provide a period of fire resistance, unless they form part of an escape route.

The fire resistance requirements are satisfied providing the cladding system:

- Resists the passage of flames and hot gasses [integrity];
- Provides resistance to heat transmission [insulation].

For insulated panels to maintain their integrity it is essential that the steel facings remain in place and the joints remain tight.

Standard fire resistance tests only assess the performance of the insulated panels themselves including the panel-to-panel joints. They do not incorporate junctions between walls or between walls and roofs or other elements. However it is of particular importance that the complete construction will maintain its integrity in fire and that the design follows this principle. [Certain insurance industry originated tests such as LPS 1208 assess a three dimensional structure].

12.2 Structure

Where an external wall is required to be fire resisting, (e.g. because of its proximity to a boundary) any elements of structure that are required to support the wall should also be provided with the same level of fire resistance. This can be achieved by providing structural fire protection to the relevant beams and columns to ensure they achieve the same standard of fire resistance.

Alternatively the Steel Construction Institute (SCI) have published a Guide [19] which provides a method of designing portal frame columns such that they are able to resist collapse without the application of applied fire protection to the portal rafters. Essentially the SCI guide requires that the columns and their bases have the capacity to resist the overturning moment induced by collapse of the portal rafters.

12.3 Insulated panels

Guidance in support of building regulations recommends a resistance to the passage of flames (integrity) and heat (insulation) for defined periods. Some mineral fibre cored panels are capable of providing 120 minutes integrity and insulation.

Certain types of system with a PIR core can achieve 120 minutes integrity and 15 minutes insulation. This will satisfy many applications for external walls located more than one metre from the boundary.

For requirements in excess of 15 minutes insulation and for all internal compartment walls it is necessary to use insulated panels with high density mineral fibre cores.

12.3 Detailing – external insulated panels

The recommended details shown in section 11 for normal panel installation apply equally where fire resistance is required. Steel flashings and closures should be used to ensure that the panel ends and any cut sections are fully protected.

Designers should confirm that site applied seals and cavity fill foams will not degrade the fire performance of the fire resisting system.

Where a fire resisting door is to be fitted into a fire resisting wall, the door and frame assembly should have been tested or assessed to BS 476 Part 22 or BS EN 13501 and in compliance with the integrity criterion for the required period. The performance should be achieved with the doors installed in a construction similar to that into which the assembly is to be fitted in practice. It is inappropriate to use a door that has only been tested in a masonry enclosure in a metal panel that may be subject to distortion under fire conditions.