December 2019

GD33 FASTENERS FOR METAL ROOF AND WALL CLADDING: DESIGN, DETAILING AND INSTALLATION GUIDE

1.0 INTRODUCTION

All roofing and cladding systems adopting profiled metal as the external surface, usually steel or aluminium, rely upon mechanical fasteners to secure the system to the structure. The importance of the correct selection of such fasteners is often underestimated by architects, designers, system suppliers and contractors and therefore, this guidance document seeks to give a comprehensive practical guide on the selection, use and performance of fasteners designed for use within the popular metal roofing and cladding systems selected by the UK market for modern industrial, commercial and residential buildings.

The guidance in this document is generally consistent with that given within BS 5427:2016+A1:2017 *Code of practice for the use of profiled sheet for roof and wall cladding on buildings*, MCRMA Technical Papers and Guidance Documents and relevant NFRC (National Federation of Roofing Contractors) publications, as well as manufacturers and original equipment manufacturers' (OEMs) documents and recommendations.

Note: A comprehensive index can be found on page 49.

2.0 DEFINITIONS

2.1 Fixing

A system of connection between two or more components.

2.2 Fastener

The mechanical connecting device used for the fixing.

2.3 Primary fastener

A fastener that secures the profiled sheeting, bracket or secondary steel to the supporting structure e.g. sheeting to structure or spacer, spacer to structure.

2.4 Secondary fastener

A fastener that secures the laps of profiled sheets to each other but not to the supporting structure; and also used to attach lightweight flashings to profiled sheeting.

2.5 Cladding

For the purposes of this paper, cladding refers to a roof or wall covering comprising of metal profiled sheeting. The cladding may be either an uninsulated sheet or an insulated system. Insulated cladding systems may be either factory formed composite panels or site assembled.

3.0 FASTENER TYPES

3.1 Primary fasteners

Primary fasteners are used to transfer all the loads; design, dead, imposed and wind; acting on the cladding system back to the supporting structure and are therefore relied upon for their structural performance. The “supporting structure” is not solely limited to the main structural steelwork i.e. column, beam, rail and purlin, and would also include the spacer system and the structural liner/deck and any secondary steelwork, where applicable.

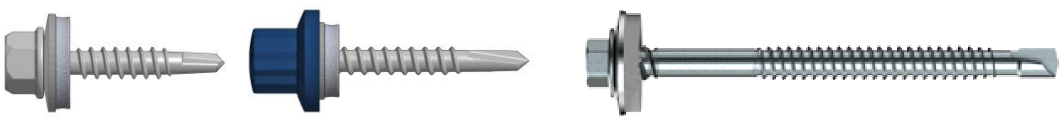

Fig 1: Examples of primary fasteners

Where the primary fasteners are exposed, they may have to provide a weathertight seal under all these load conditions including repetitive dynamic movement of the sheet. Additionally, where primary fasteners are exposed, they are normally required to be coloured to match (or even contrast!) the material they are securing.

For metal cladding systems, primary fasteners are usually threaded and installers often prefer to use the ‘self-drilling’ type due to their speed of single operation installation. The alternative to self-drillers are ‘self-tappers’ which require a pre-drilled pilot hole prior to installing the fastener. Other non-threaded fasteners may also be suitable in some applications for example, rivets.

3.2 Secondary fasteners

Unlike primary fasteners, secondary fasteners are not generally relied upon for structural performance, however, they must be capable of providing a secure fixing. In certain applications, for example where secondary fasteners are used to provide lateral restraint or where they are part of a stress skin design, secondary fasteners are required to transfer loads and their shear strength would have to be considered in the structural calculations.

Fig 2: Examples of secondary fasteners

For metal cladding systems, secondary fasteners are typically used for sheet side lap stitching and the securing of flashings and ancillary components to the sheeting. In order to provide a high degree of clamping to both compress any sealant and to draw the joint tightly together without thread stripping, stitching fasteners (stitchers) must be purpose-designed. Where secondary fasteners are exposed, or part of an air/vapour control layer, they may also need to provide an air/weathertight seal and/or colour matching.

As with primary fasteners as noted above, secondary fasteners are also usually threaded and installers often prefer to use the 'self-drilling' type due to their speed of single operation. Other non-threaded fasteners may also be suitable in some applications for example, rivets.

3.3 Self-drilling fasteners

Self-drilling fasteners require no pre-drill operation and are therefore often preferred by the installer. The fasteners integral drill point enables the fastener to self-drill, thread form, and be set/tightened in a single continuous operation. with a single purpose-designed. This single operation with a self-drilling fastener also ensures alignment of the two components. Self-drilling fasteners should be installed with a

purpose-designed screw gun fitted with correctly set depth locators or torque control devices.
The drilling speed of the screw gun is usually in the 1800-2600 rpm range, however, the fastener supplier should provide their recommendations on the correct installation methods, including the relevant tooling and running speeds for each specific fastener type. Impact drivers should be avoided as they are generally not suitable for self-drilling fasteners.

Fig 3: Examples of drill points on self-drilling fasteners

Self-drilling fasteners are available with a range of point configurations designed for specific drilling capacities and manufacturers advise the minimum recommended thickness as well as the maximum drilling capacity for each type, for example 1.2 to 3mm. The maximum drilling capacity of self-drilling fasteners is typically 12mm although some manufacturers may have self-drilling fasteners which can exceed 12mm.

Where the component to be drilled into, usually the structural purlin/rail/or frame, exceeds the maximum drilling capacity of the fastener, then a pre-drill operation would be necessary prior to installing the fastener (self-tapper, section 3.4 below).

Self-drilling primary fasteners typically have a minimum thread diameter of 5.5mm and secondary fasteners a minimum diameter of 4.8mm. The thread pitch may also vary between fasteners for different substrate thicknesses, for example some manufacturers adopt a fine (close) thread configuration for self-drillers into hot rolled steel and a coarser pitch for thinner cold-rolled sections.
A visual inspection of the thread may not specifically indicate the material thickness that the fastener is designed for therefore the manufacturer/supplier should be consulted for advice on correct selection.

For some ‘thin’ applications, typically <1mm steel or <1.5mm aluminium, self-piercing fasteners may be used. These have a sharp hardened needle point rather than a drill point. As well as giving relatively high pull-out values, self-piercing fasteners tend not to generate swarf.

3.4 Self-tapping fasteners

Self-tapping fasteners have no drill point and therefore a predrilling of a pilot hole is necessary in both/all components being fastened. The installer requires two tools and two separate operations to install each fastener, thus making them significantly slower than self-drillers.

When using self-tappers, it is important that the correct pilot-hole size is drilled in order that optimum pull-out and clamping performance is achieved. This requires careful selection of the drill diameter.

Fig 4: Examples of self-tapping fasteners

The use of worn drill bits should be avoided. Holes should be drilled perpendicular to the material without oscillating the drill as this could affect the overall size and shape of the pilot hole.

Oversize/mis-shaped holes reduce pull-out performance and undersize holes may prevent the fastener from being installed and subject the fastener to undue torsional stresses.

Self-tapping primary fasteners typically have a thread diameter of 6.3mm. There are different thread and lead-in configurations available specific to the fastener material and the material into which the fastener has to threadform, ie cold or hot rolled steel, timber or masonry.

Unlike self-drillers, self-tappers are not limited to 12mm substrate thickness. However, installation testing is advisable above this thickness to determine the optimum predrill diameter. As with self-drillers, there are purpose-designed screw guns for self-tappers. Usually the speed for self-tappers should be reduced to c600rpm however, the fastener supplier should provide their recommendations on the correct installation methods

3.5 Other fastener types

Self-drilling and self-tapping fasteners referred to in sections 3.3 and 3.4 above are normally of the threaded type, and, whilst these are the most widely used type, many other types of fastener are available for specific primary and secondary fixing applications within the metal cladding market. These include:

3.5.1 Rivet type fasteners

These are most widely used for secondary fixing, typically for connection to thin materials such as side laps on profiled sheeting and for flashings (section 6.6). Certain types of rivets may be used for primary fixing, for example for fixing rainscreen/façade panels back to "thin" (typically <2mm) aluminium rail systems where there may be the risk of overdriving and/or unwinding due to repetitive thermal movement.

As with self-tapping threaded fasteners, rivets need to be applied through correctly sized and formed pilot-holes. Rivets are available in a number of materials and can normally be supplied with sealing washers and coloured heads where required'

Fig 5: Rivet type fasteners

3.5.2 Grommet type fasteners

When connecting profiled sheet sidelaps to a GRP or 'plastic' rooflight material, (see section 5.7), and where the rooflights do not have a metal strip factory-fitted in the underlap, the fixing recommendations of the rooflight supplier should be followed. Grommet type secondary fasteners are usually recommended.
The grommet usually comprises of a central threaded set screw assembled into an elastomeric sleeve (usually EPDM or neoprene for special applications) which has a nut encapsulated at its lower end.

The assembly is inserted into a correctly sized pre-drilled pilot hole. Upon tightening, the nut draws the flexible sleeve up the fastener shank thus compressing and cushioning the sleeve around the materials being connected. Grommets should normally be installed at low speed by hand rather than with screw guns.

Fig 6: Grommet type fasteners

3.5.3 Expanding and friction type anchors

These provide a further method of fixing cladding components back to a concrete type substrate.

This type of fastener is usually two-part with an outer sleeve, typically metallic or plastic, which expands when the internal part of the fastener is “installed”. Pre-drilled holes are usually required and the expansion of the installed product either displaces/undercuts the substrate or produces high levels of friction against the substrate wall to provide the performance.

A wide range of products is available with different performance levels within substrates over a broad range of densities, therefore, advice should also be sought from the supplier on product selection and performance. Edge distances, spacing and embedment depths are of particular importance with these types of anchors.

Fig 7: Expanding and friction type anchors

It is advisable to carry out site pull-out tests when fixing primary fasteners into concrete or masonry unless the substrate specification is known and the anchor selected has a European Technical Approval (ETA) enabling the engineer to use the ETA data to calculate the anchor design load and frequency in the specific application.

Additional guidance may be sought from BS 8539:2012 *Code of practice for the selection and installation of post-installed anchors in concrete and masonry* and also from the Construction Fixings Association (CFA) https://www.the-cfa.co.uk

4.0 PERFORMANCE CRITERIA

BS 5427:2016+A1:2017 *The code of practice for the use of profiled sheet for roof and wall cladding on buildings*, the MCRMA guidance documents and other industry publications such as the NFRC Blue Book give extensive detailed references for the design and performance requirements of metal cladding systems.
Fasteners are vital to all these systems and provide a specific range of functions which should all be considered in order to make an appropriate selection.

The functions of fasteners may be split into four sections:

- Durability
- Weathertightness
- Aesthetics
- Structural

This section will address these in **general** terms, and where the fastener performance is specific to the type of roofing system, this will be dealt with in more detail under the relevant part of section 5.0.

4.1 Durability

A fastener must have a level of durability compatible to the intended functional lifespan required of the selected cladding system in the particular application. Fasteners are available in a number of materials all of which offer different levels of corrosion resistance/durability when exposed to a variety of conditions, both external and internal.

BS 7543:2015 *Guide to durability of buildings and building elements, products and components* gives some guidance on design life requirements of buildings and components within the construction.

By reference to Table 1 of BS 7543 fasteners should not be classed as either ‘replaceable’ or ‘maintainable’ but should be ‘lifelong’ that is, to the design life of the material or system within which they are used. Refer also to diagram reproduced from BS 7543 shown overleaf

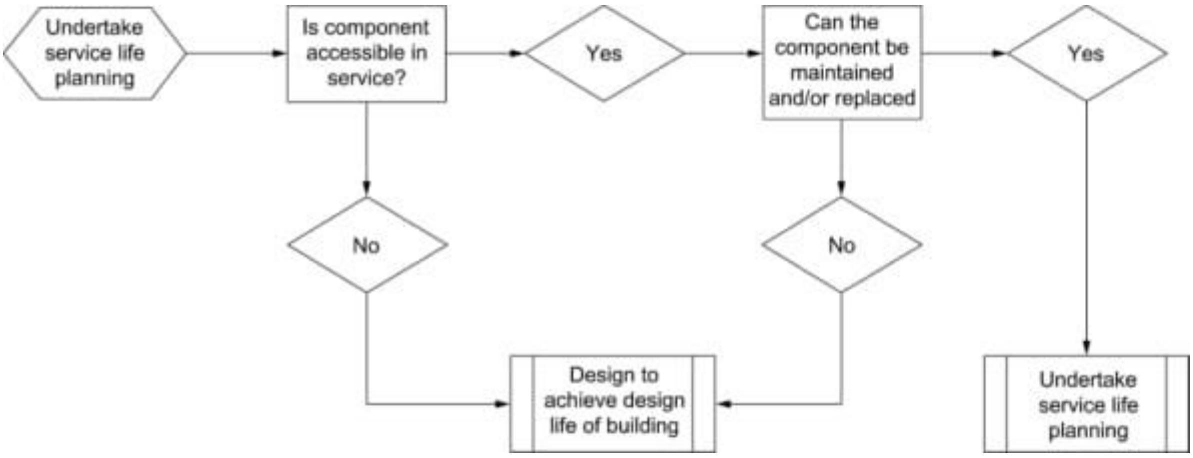

Table 1: BS 7543 decision process in support of categorisation of design life © British Standards Institute

BS EN ISO 12944-2 *Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Classification of environments* gives guidance on atmospheric environments which are classified into six atmospheric-corrosivity categories C1, C2, C3, C4, C5-I and C5-M as Table 2 below.

Corrosivity category	Mass loss per unit surface/thickness loss (after first year of exposure)				Examples of typical environment (informative only)	
	Low carbon steel		Zinc		Exterior	Interior
	Mass loss g/m^2	Thickness loss µm	Mass loss g/m^2	Thickness loss		
C1 very low	≤ 10	≤ 1.3	≤ 0.7	≤ 0.1	-----	Heated buildings with clean atmospheres, e.g., offices, shops, schools, hotels
C2 low	> 10 to 200	> 1.3 to 25	> 0.7 to 5	> 0.1 to 0.7	Atmospheres with low level of pollution: mostly rural areas	Unheated buildings where condensation can occur, e.g. depots, sports halls
C3 medium	> 200 to 400	> 25 to 50	> 5 to 15	> 0.7 to 2,1	Urban and industrial atmospheres moderate sulphur dioxide pollution: coastal areas with low salinity	Production rooms with high humidity and some air pollution e.g. food processing plants, laundries, breweries, dairies
C4 high	> 400 to 650	> 50 to 80	> 15 to 30	> 2.1 to 4.2	Industrial areas and coastal areas with moderate salinity	Chemical plants, swimming pools, coastal ship and boatyards
C5 very high	> 650 to 1500	> 80 to 200	> 30 to 60	> 4.2 to 8.4	Industrial areas with high humidity and aggressive atmosphere and coastal areas with high salinity	Buildings or areas with almost permanent condensation and with high pollution
CX extreme	> 1500 to 5500	> 200 to 700	> 60 to 180	> 8.4 to 25	Offshore areas with high salinity and industrial areas with extreme humidity and aggressive atmosphere and sub-tropical and tropical atmospheres	Industrial areas with extreme humidity and aggressive atmosphere
NOTE: The loss values used for the corrosivity categories are identical to those given in ISO 9223						

Table 2: BS EN ISO 12944-2:2017

Atmospheric-corrosivity categories and examples of typical environments

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Threaded self-tapping and self-drilling fasteners are available in a range of materials; carbon steel, stainless steel and aluminium.

4.1.1 Carbon steel threaded fasteners

Unprotected carbon steel will corrode when exposed to the atmosphere. The rate of corrosion may be rapid and depends upon the environmental conditions. Carbon steel fasteners for metal cladding are therefore surface coated to extend the durability of the product. The surface coating generally available for such fasteners may be zinc or zinc with an additional organic or polymeric coating.

It must be recognised that, as part of a metal cladding system, these surface coatings will inevitably receive a degree of damage during installation through metal components, for example the profiled sheet and the spacer system or purlin/rail, which will reduce their durability in certain applications.

Clause B.1.2.4 of BS7543: 2015 states…. "*The pollution (corrosion) of zinc in dry, unpolluted environments is very slow. It is accelerated in the presence of moisture (roughly four times as fast), and significantly increased (roughly ten times as fast) in polluted, moist conditions" … "Where used as a protective coating over mild steel damage or partial removal and/or degradation of the zinc coating will accelerate corrosion of the base steel which the coating is designed to protect"*

Coated carbon steel fasteners have been shown to be suitable for many roofing and cladding applications where there is not the risk of corrosive internal and external environments and where the functional life expectancy, not a warranty, required of the fastener and cladding system does not exceed approximately 25 years. External/exposed carbon steel fastener heads should be protected from low corrosion-risk external environments by factory 'colouring' or integral plastic heads to provide this functional life.

Carbon steel fasteners should **not** be used with aluminium (or stainless steel) profiled sheeting or components unless the fasteners are internal and the internal conditions are limited to Corrosivity Categories C1 and C2 from Table 2 above.

4.1.2 Stainless steel threaded fasteners

Stainless steel is a generic term and there are over 200 grades. Not all grades are suitable for metal cladding fasteners. Of the grades recommended in BS 5427:2016+A1:2017 for stainless steel roofing and cladding fasteners, EN 1.4301 (A2, 304) and EN 1.4401 (A4, 316) are the typical grades used and these would be considered suitable for the majority of applications. However, for example, refer to 6.11 - swimming pools where these grades (A2, 304 or A4, 316) may not be suitable.

The designer should ensure the suitability of the fastener specification for the particular application/construction. The fastener manufacturer/supplier will provide performance data for their products and advise on suitability of the grades in specific environments.

Appropriate grades of stainless steel fasteners can provide enhanced durability and corrosion resistance over coated carbon steel fasteners as referred to in section 4.1.1 above and could therefore provide a functional life expectancy, not a warranty, exceeding 25 years even in aggressive conditions C4, C5-I and C5-M where the appropriate grade is selected. However, in these conditions the manufacturer/supplier should always be consulted to determine the most suitable fastener (see section 6.11).

Stainless steel fasteners can be manufactured wholly from stainless steel in self-tapping and self-drilling forms. To enable stainless steel fasteners to self-drill through and into steel, the fasteners may have a heat-treated and hardened carbon steel drill point. These are often referred to as ‘bi-metal’ fasteners. The design and selection must ensure that, when installed, all threads within and above the support are stainless and not carbon steel.

To enable stainless steel fasteners to drill through and into aluminium there is not the need for a bi-metal fastener as the stainless drill point is sufficiently hard to drill aluminium.

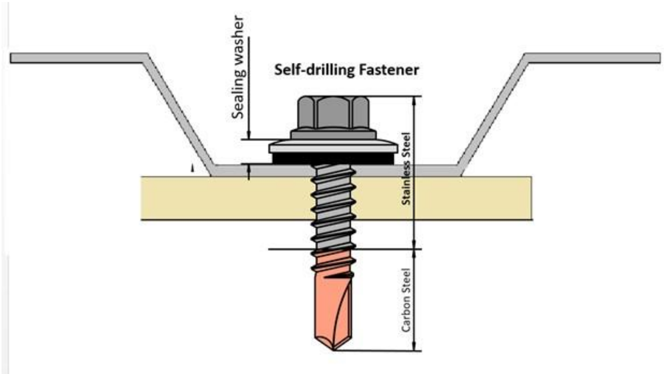

Fig 8: Stainless steel self-drillers – all threads within and above purlin must be stainless

4.1.3 Aluminium threaded fasteners

Aluminium is regarded as a highly durable material, exceeding the durability of coated carbon steel but not matching the corrosion-resistance of stainless steel. Aluminium self-drilling fasteners cannot be used in conjunction with steel purlins, spacers or cladding as the aluminium does not have sufficient hardness to drill or thread form into steel.

So, the applications within metal cladding for which aluminium threaded self-drilling fasteners can be considered are restricted. They may be considered as primary fasteners for securing only aluminium and certain ‘plastic’ cladding profiles to timber supports and also as secondary (stitching) fasteners within aluminium profiles.

4.1.4. Fastener material selection

For the recommended fastener material to suit BS EN 12944 exposure categories, refer to the online NFRC Blue Book Part 7 for guidance on the anticipated functional life expectancies of coated carbon and stainless steel fasteners in differing exposure categories.

4.1.5. Coastal zones – C4 Exposure Category to BS EN ISO 12944-2:2017 *Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Classification of environments*. There is no British Standard which clearly defines the extent of coastal zones around the British shoreline. However, there are a number of references that may be used as a guide in order to select the most suitable fastener material in these environments.

- **BS 7543:2015 – Clause A.1.3. Coastal regions**… *"Sea fogs or mists might also linger within several miles of coasts. Particular consideration should be given to wind-blown salt atmosphere and how far inland this might impact the design specification."*
- **BS EN ISO 12944-2:2017** "*3.7.4. marine atmosphere. The atmosphere over and near the sea. NOTE: A marine atmosphere will extend a certain distance inland, depending on the topography and prevailing wind direction. It is heavily polluted with sea-salt aerosols (mainly chlorides).*
- **International Molybdenum Association (IMOA)…. Which stainless steel should be specified for exterior applications?**
  Coastal and marine exposure. *"Local wind patterns determine how far sea salts are carried inland. Generally, locations within 8-16 kilometres of salt water are considered coastal. In some locations, salt is carried a relatively short distance inland, and, in others, it can be carried much farther than 16 kilometres."*

Bear in mind also that the fastener is a critical component to maintain the structural integrity of the roofing/cladding. Very often the fasteners do not have the benefit of being regularly 'washed' by rainwater to minimise the build-up of the corrosive chlorides.

The roof sheet/panel is more able to maintain its structural capacity for longer periods in this corrosive coastal environment and the periods may be extended by overpainting when necessary.
This does not however apply to the fasteners where any corrosion could lead to structural problems. Therefore, caution needs to be taken in the selection of fastener material to comply with the required functional (and warranty) periods.

Note:
Taking this into account, it would be prudent from a fastener viewpoint, to consider a C4 Coastal Zone as extending 10 kilometres from the high tide mark along the coastline and also five kilometres from tidal rivers where the tidal reach from the coastline/river mouth exceeds the 10 kilometres as above.

4.2 Weathertightness

Normally this weathertightness requirement of fasteners relates only to exposed external fasteners. However, the ability of a fastener to maintain a seal is often required on certain internal fasteners where the restriction of air and vapour diffusing into the system is desirable or to meet air permeability requirements within the Building Regulations.

The ability of a fastener to re-seal holes made in the cladding profile depends primarily on the design and performance of a compressible sealing element. The sealing element must be resilient to the mechanical forces to which it is subjected during installation of the fastener, the clamping and service loads in use, as well as the environmental and mechanical conditions encountered during its service life.

It is generally recognised that ethylene-propylene-diene-monomer (EPDM) provides the best all-round performance for the sealing element. EPDM may be formulated to maintain its elasticity and remain stable under all conditions including temperature extremes, moisture, UV light, ozone and both general atmospheric and aggressive industrial pollutants. The thickness and hardness of the sealing material should be designed specifically for the fastener application to ensure adequate sealing.

To ensure the sealing element is held in place and prevented from excessive 'extrusion' away from the fastener shank during installation, the EPDM may be bonded or vulcanised to a metal backing washer. This metal washer should have a corrosion resistance compatible with the fastener material and should be of sufficient metal thickness and shape to resist inversion/pull-over loadings resulting from wind suction, angular driving and typical site installation practices (refer to section 4.4.4) whilst maintaining the clamping load of the fastener.

Some manufacturers/suppliers offer a separate EPDM seal and a flanged head to the fastener. Whilst this may provide excellent inversion/pull-over resistance, the underside of the head must be purpose-designed to retain and control the extrusion of the EPDM seal under all conditions.

The washer compression will also provide a visible indication of the correct installation of the fastener and assist in preventing overdriving (or under driving) the fastener.

The diameter of the washer/sealing elements available range typically from 10mm to 32mm. The selection relates to the sheet material and degree of exposure ie roof or wall, and whether the fastener is used in a primary or secondary application.

As a guide, the following minimum diameters shown in Table 4 can be used but reference should be made to section 5.0 where more specific guidance is given.

Material	Roof	Wall
GRP/PVC primary fasteners	29-32mm	29-32mm
Aluminium sheet primary fasteners	19mm	15mm
Steel sheet primary fasteners	15mm	15mm
Secondary stitching fasteners	10mm	10mm

Table 3: Minimum diameters

Saddle washers. Some profile manufacturers and installers have a preference in certain applications to position the main fix on trapezoidal profiles at the crown. This typically applies to polycarbonate rooflights, aluminium profiles and also sinusoidal profiles, but could also be used at end laps and four lap conditions to assist in sealant compression. In these conditions, an additional saddle washer can be used which helps spread the compression load and can provide increased pull-over loads. The profile manufacturers' recommendations should be understood and followed.

4.3 Aesthetics

This functional requirement of fasteners relates only to those which are visible once installed. The industry standard headform for a self-drilling/ self-tapping non-coloured fastener is an 8mm (5/16") hexagon, measured across flats, typically 4-5mm deep. Below the hexagonal portion there would be either the bonded washer or the flange as referred to in section 4.2 above.

Through-fixed profiled metal cladding is predominantly colour-coated, other than relatively low volumes of mill-finish or stucco-embossed aluminium, plain galvanised steel and plain zinc/aluminium coated steel.

The original method used by the installer to colour match ‘standard’ fastener head forms was to site-apply a push-fit plastic cap. Whilst this method may have been economic in terms of components, it proved to be labour intensive for the installer and, in many cases, an unsuccessful colour match for the client in terms of long term stability and durability.

Push-fit caps can easily be picked off; they rarely have equal levels of colour fastness offered by colour coated metals; they are prone to UV degradation; and they can, if not suitably designed or installed, entrap moisture which could accelerate corrosion of a carbon steel headed fastener leading to unsightly rust stains down the cladding.

For the installer, applying push-fit caps is another operation which could be avoided. Missing or dislodged caps are a common item on many snagging lists and the access and labour required to replace them adds disproportionately to the contractor’s costs. Push-fit caps are therefore not generally recommended by manufacturers/suppliers. There has been a significant trend away from push-fit caps to factory coloured ‘integral’ heads.

4.3.1. Factory coloured moulded heads

This head form usually involves moulding a coloured plastic/nylon head over the metal head of the fastener. Some manufacturers mould around their standard hexagonal headform which may or may not be flanged, and some mould around a special non-hexagonal headform. The finished moulded headform may either be hexagonal or bi-hexagonal.

Whichever method is selected, the design should not result in long term permanent loads being transmitted by the compressed sealing element directly onto the plastic/nylon alone as this may lead to premature moulded head detachment. The load should always be transmitted back through the sealing element to the metal portion of the fastener head.

4.3.2. Painted fasteners

As an alternative to moulded heads as described above in 4.3.1., fasteners may be colour matched by means of factory applied ‘painting’, usually a resilient and colour stable powder coating, to the hexagonal steel head and washer face.

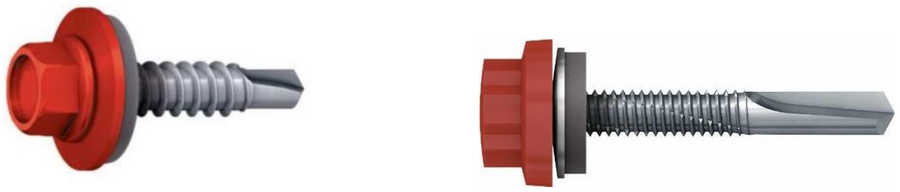

Fig 9: Factory coloured integral and painted heads

Painted fasteners are also available with lower profile headforms for applications where the client wishes the fastener heads to be as unobtrusive as possible. This requirement is normally associated with walling applications and, in particular, with side lap stitchers and flashing details.

Fig 10: Low profile head

Frequently these self-drilling low profile colour-headed fasteners are chosen as an alternative to rivets and push-on caps due to their speed of installation as well as the preference for factory coloured heads as referred to above.

On both the moulded heads and the painted heads, it is extremely important the correct sockets are used appropriate to the particular headform and also that fasteners are installed with the correct tooling as recommended by the manufacturer/supplier (refer to section 7.0 Installation/tooling and MCRMA GD32 *Self drilling fastener installation tools*).

Even though these factory coloured headforms may give, in some instances, added corrosion resistance to the exposed head portion of the fastener, BS 5427:2016+A1:2017 states that *"this should not be relied upon as the sole basic protection against corrosion"*. As referred to in sections 4.1.1 and 4.1.2 above, the corrosion resistance/durability of the fastener is attributed to the fastener material.

It is extremely important that the correct socket is selected appropriate to the particular fastener headform. Furthermore, to avoid damage to the fastener head, to the washer and, not least, to the connection in the supporting material/structure, it is equally important that screw guns are fitted with correctly set depth locators or torque-control devices. The fastener supplier should provide their recommendations on the correct installation methods, including the relevant tooling and running speeds (refer to section 7.0 Installation/tooling and MCRMA GD32 *Self drilling fastener installation tools*).

4.4 Structural

In addition to satisfying the durability, weathertightness and aesthetic functional requirements, the fastener also has to be capable of withstanding a wide range of types of loading. Some types of loading apply to virtually all metal cladding fasteners regardless of their application, whereas some loadings are specific to the system in which the fastener is incorporated.

The loadings which apply to most fasteners include:

- Tensile loads — pull-out and pull-over resistance
- Shear loads — shear force resistance
- Installation loads — overdrive resistance
- Clamping loads — firmly securing the material to the support or clamping material to material (stitchers)

Loadings which tend to be specific to the cladding system include:

- Bend resistance — composite panel fasteners
- Pushdown resistance — composite panel fasteners
- Clamping — stitching fasteners
- Thermal movement — fasteners for aluminium fabrications
- Thermal movement — fasteners for aluminium rainscreen supports

This group of structural performance requirements is dealt with under the relevant part of sections 5.0 and 6.0.

4.4.1 Pull-out resistance

This is the ability of a fastener's connection within its supporting material to remain intact and resisting being 'pulled out' due to tensile loadings. The other tensile loading is pull-over. A wide range of substrates will offer differing resistance to pull-out.

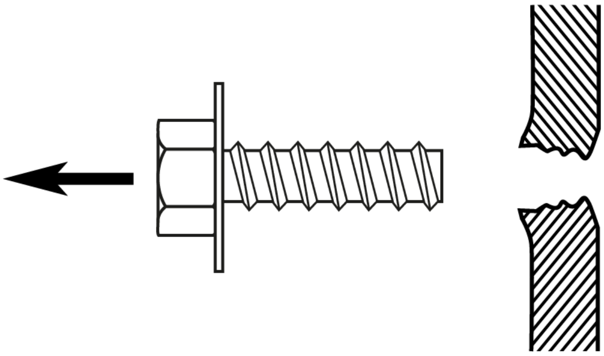

Fig 11: Pull-out resistance

As the UK metal cladding market frequently involves primary fixing into relatively thin cold rolled steel purlins, steel and aluminium rails and spacing systems, pull-out of primary fasteners is one of the most critical of the loadings that should be considered. Timber plywood and sheathing boards are becoming more popular, especially with rainscreen cladding and facades, therefore choice of fastener type and relative pull-out performance from the specific substrate needs careful consideration.

Where the structural performance of any fastener is concerned the lowest tensile failure mode should be taken into consideration, this may be from pull-out or from pull-over therefore pull-out should not be taken in isolation.

With threaded fasteners, the ability to resist pull-out/tensile loadings relates to the combination of thread diameter, drill point diameter and support material thickness and grade. As a general rule, the drill point diameter, or pre-drill in the case of self-tappers, reduces relative to the thread diameter as the support material reduces in thickness.

As noted in section 3.3, self-drilling fasteners for metal cladding systems have drill points purpose-designed for the thickness of the support they drill through.

Thus, providing the installer selects the correct product for the application, he will achieve optimum pull-out performance providing the fastener is installed as recommended by the manufacturer/supplier using screw guns fitted with depth locator or torque control devices.

Where self-tapping fasteners are selected, the installer must ensure he uses a drill bit that is in good condition and of a diameter recommended by the fastener supplier appropriate for the support thickness. Failure to follow this guideline will result in reduced pull-out values if the hole is too large or mis-shaped, or installation problems if the hole is too small (refer to section 3.4).

BS 5427:2016+A1:2017 gives some typical methods for testing the tensile and shear strength of fasteners and there are various other internationally recognised and accepted industry tests adopted by manufacturers. This means that similar fasteners, which are designed for the same purpose, from different manufacturers may have quite different published strengths because of the different test methods used.

Furthermore, the test methods do not necessarily reproduce the realistic application of the fastener in a particular metal cladding system (and its supports), so simply comparing fastener manufacturers published pull out values should be treated with caution. Some manufacturers/suppliers have products which have an ETA. These products have been independently tested and assessed to a consistent methodology and the performance data contained in the ETA and published by the relevant Approved Body in the certification gives a realistic comparison.

Manufacturers and suppliers of fasteners should have available their products' typical ultimate failure values, together with their standard deviation (based on their own particular test). The contractor or designer should also obtain advice from his cladding system suppliers to ensure the proposed fastener type and frequency can accommodate all design loadings, using the appropriate safety factors detailed in Annex B of BS 5427:2016+A1:2017 or the ETA where applicable.

Rivet type fasteners resist these loadings by expanding on the underside of the supporting material however, it should be recognised that with certain types of rivet, particularly those manufactured from aluminium, the rivet body may fail in tension before it pulls out of the support. Advice and documentation, ETA where available, should be obtained from the supplier.

4.4.2 Pull-over resistance

This is the ability of the fastener to prevent the sheet material failing under tension by pulling over the head of the fastener. Pull-over resistance of fasteners should always be considered particularly within applications incorporating steel profiles typically less than 0.7mm thickness, aluminium profiles, GRP/PVC profiles, and applications including support structures thicker than 1.5mm, as pull-over failure may occur at a lower value than pull-out failure.

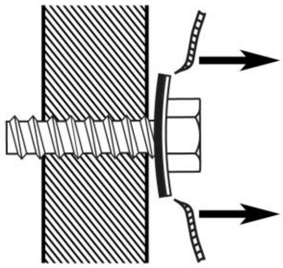

Fig 12: Pull-over resistance

The principal resistance of any fastener to pull-over is provided by the headform/washer combination. Section 4.2 illustrates how the headform and washer design can ensure weathertightness. The pull-over forces have to be resisted by the metal backing of the bonded washer or the flanged head. Bonded washers are available in a range of diameters from 10mm up to 32mm, and where the pull-over risk increases then it would be normal practice to increase the washer diameter. Flanges are typically restricted to 15mm diameter and therefore, with some sheet materials and loading conditions, it may be necessary to incorporate a bonded washer of increased diameter under the flanged head. The designer/installer must ensure that the washers are of sufficient metal thickness and shape to resist the loads.

As with pull-out, there are industry tests available, including those described within BS 5427:2016+A1:2017 and manufacturers/suppliers should publish or have test values available. Pull-over would also be considered along with pull-out and the relevant values used in design would be published in the ETA where applicable.

4.4.3 Shear force resistance

Fasteners have to resist shear, lateral, thermal and differential movement and from bending at rotational moments in respect of long fasteners associated with composite panels. Performance is derived from the components and material of the installed system as well as the fastener material and diameter. This aspect of the fasteners performance is critical in many roofing and cladding systems and also where high shear loadings are required for brackets and structural cladding systems. Fastener manufacturer's performance tables, or ETAs where applicable, should be consulted with regards the fastener components individual shear performance for fastener selection.

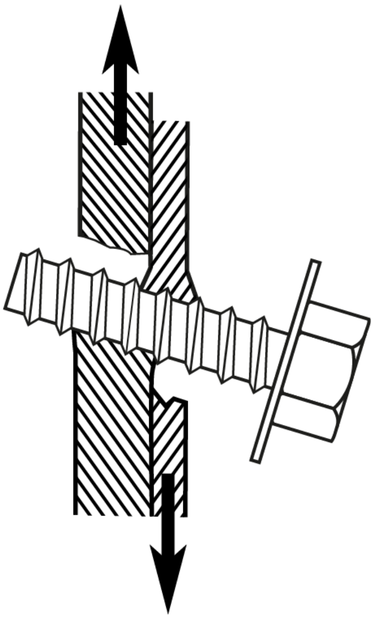

Fig 13: Shear load resistance

Shear loads reactions can be complex. These forces can either affect the shear of the fastener itself or shearing forces within the application tearing and elongating the materials. The shear forces in many instances may be quite low compared with tensile, pull-out or pull-over, forces but how the liner or sheet reacts to these forces, elongation can occur.

Although this may not be seen as a performance issue it may, in some circumstances, reduce pull-over and in thin substrates the shear forces may also reduce pull-out. The choice of washer diameter to ensure clamping forces are maintained and the location and position of the fastener within the system and quantity of fasteners is essential.

Note: Stressed skin design roof systems have not been included in this guidance document and therefore where fasteners are intended for use in such shear load applications then reference should be made to either BS EN 1993-1-3:2006 Eurocode 3 *Design of steel structures. General rules. Supplementary rules for cold-formed members and sheeting*, or the system supplier for guidance on fastener selection and performance.

4.4.4 Installation loadings

Undoubtedly, one of the most aggressive loads to which fasteners for metal cladding systems are subjected are those loads applied during the installation process. Fasteners need to be installed accurately to ensure a) that the clamping loads are achieved, b) the washers, where required, are compressed to provide a water and air/vapour seal and most importantly c) that the thread engagement with the substrate is sufficient to resist the loadings of the application without stripping of the thread of the fastener or the substrate.

For the fastener to achieve the optimum performance, it must not be under driven (this can create a gap between the head and the material being clamped and may prevent the washer from effecting a seal, which may led to water ingress and/or air leakage), and must not be overdriven (this can cause stripping of the fastener in the support, damage to the material being clamped, or dimpling of a composite panel outer skin, and will over compress the washer lifting the EPDM at the edge to allow moisture and dirt to sit under the washer surface. This will cause washer inversion and can reduce the pull-over performance in the application.

The key to correct fastener installation and therefore achieving optimum performance, lies in the selection and use of tooling appropriate to the fastener type and application. Most fastener manufacturers/suppliers will recommend and/or supply tooling with which their products may be installed. Guidance on the correct installation speeds, end loads and sockets/drive bits for the differing fastener types should also be available.

Tools must be maintained and both fastener and metal roofing system suppliers recommend that screw guns are fitted with correctly set depth locators or torque (where the fastener type is installed by torque) control devices.

Fig 14: Examples of typical screw guns

Some fastener manufacturers/suppliers can provide bespoke tooling and drive systems which, as well as often increasing the speed of installation, can ensure correct and consistent fastener setting. Impact drivers should be avoided as they are generally not suitable for self-drilling or self-tapping fasteners (refer also to Section 7.0 Installation/tooling and MCRMA GD32 *Self drilling fastener installation tools*).

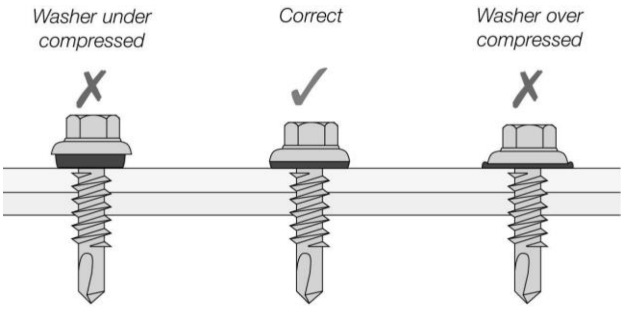

Fig 15: Correct installation for primary fasteners

5.0 TYPICAL CLADDING SYSTEMS

This section takes each of the popular cladding systems selected by the UK market for modern industrial and commercial buildings and gives more specific guidance on the selection of fasteners in order that client expectations may be met. Unless specifically noted otherwise, the choice of fastener material is left for the designer/ system supplier/contractor to determine by making reference to section 4.1. Similarly, the fastener types referred to are generally self-drillers, other than the rivet/grommet type referred to in section 3.5.

5.1 Single skin metal cladding

Consisting of a single sheet fixed directly to the structure, acting solely as a watertight skin and providing no thermal or acoustic benefits.

5.1.1 Trapezoidal steel sheet, pre-coated

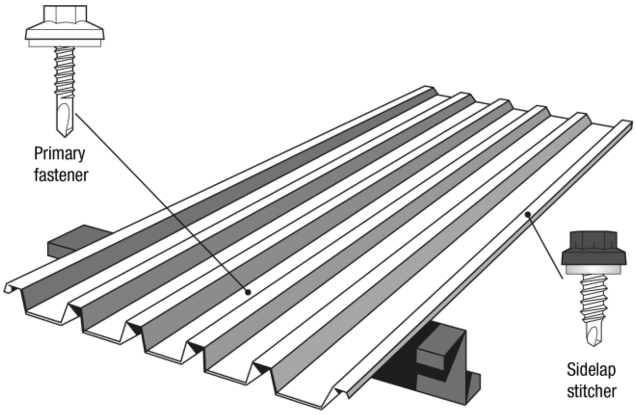

Fig 16: Single skin construction

Materials for the fasteners are normally coated carbon steel or stainless steel depending upon the system material and the required durability – refer to section 4.1.

a) Primary fasteners / endlaps

Fixed in the valley of the sheet, using a minimum 5.5mm diameter fastener suitable for the substrate being fixed into. A colour-matched integral head is recommended with a minimum 15mm diameter washer for the walls and 19mm for the roof.

b) Secondary fasteners / sidelaps

Fixed in the crown of the sheet, using a minimum 4.8mm diameter stitching fastener. A colour-matched integral head is recommended with a minimum 10mm diameter washer. A low-profile head self-drilling fastener may be preferred is fixing in the crown of a wall sheet.

c) Rooflights

Where rooflights are included refer to section 5.7.

5.1.2 Trapezoidal aluminium sheet, colour coated

When using an aluminium sheet, a stainless steel fastener **MUST** be used to prevent galvanic corrosion.

a) Primary fasteners / endlap

Fixed in the valley of the sheet, with a minimum 5.5mm diameter fastener suitable for the substrate being fixed into. A colour-matched integral head is recommended with a minimum 15mm diameter washer for the walls and 19mm for the roof.

b) Secondary fasteners / sidelaps

Fixed in the crown of the sheet, with a minimum 4.8m diameter stitching fastener. A colour-matched integral head is recommended with a minimum 10mm diameter washer. A low-profile head self-drilling fastener may be preferred is fixing in the crown of a wall sheet.

c) Rooflights

Where rooflights are included refer to section 5.7.

5.2 Built-up system

Fig 17: Built up system construction

5.2.1 Liner sheet

There has been major debate within the metal cladding industry on the subject of health and safety and what is a fragile or non-fragile construction. This guidance document is not intended to give specific guidance on health and safety issues. However, tests commissioned by the MCRMA have shown that the fastener specification and frequency can play an important part in the impact resistance of the cladding system.

Materials for the fasteners are normally coated carbon steel or stainless steel depending upon the system material and the required durability– refer to section 4.1.

a) Primary fasteners / endlap

Fixed in the valley of the sheet, with a minimum 5.5mm diameter fastener suitable for the substrate being fixed into. A minimum 15mm diameter washer is recommended for the roof, and is optional for the walls.

b) Secondary fasteners / sidelap

On non-structural liners which are typically 0.4mm steel, it is not usually practical to mechanically side lap stitch, particularly on roofing applications. A 50mm x 1mm butyl tape over the lap has proven more practical where there is the requirement for seals. On firewalls it may be necessary to side lap stitch the liner panel. This is normally done with steel, not aluminium, rivets. Please refer to the system supplier (refer to section 6.9).

c) Rooflights

Where rooflights are included refer to section 5.7.

5.2.2 Spacer system

Spacer systems (or spacer kits) are used within built-up systems to create a cavity between the liner sheet and the weather sheet to allow for insulation to be installed to meet specific thermal performance requirements.

There are different types of spacer systems available in the UK metal cladding market. The two most commonly available are ‘zed and ferrule’ systems and ‘bracket and rail’ systems.

Fig 18: Bracket and rail spacer system

Zed and ferrule system

A continuous zed-shaped rail which is fastened through spacer ferrules and to the structure. The spacer ferrule is usually made of a virgin plastic (polypropylene) material or steel, if used within a firewall system (refer to section 6.9). These ferrules are spaced in accordance with individual system suppliers' recommendations.
This type of spacer system is, in general, less suitable for insulation cavity depths exceeding 100mm due to the load paths and stability.

Bracket and rail system

Although the designs of these systems vary, they are typically of a shape that allows the interlocking of the rail and the bracket. Brackets are available in varying depths to suit the required cavity depth to meet thermal requirements. Manufacturers have bracket designs which are suited to insulation cavity depths in excess of 250mm and should be able to provide load testing data. Fasteners are installed through pre-punched holes in the foot of the bracket.

Materials for the fasteners for spacer systems are normally coated carbon steel or stainless steel depending upon the system material and the required durability– refer to section 4.1.
Spacer system fasteners:

- Plain hexagon headed fasteners of a minimum 5.5mm diameter suitable for the substrate being fixed into.
- Timber and concrete substrates may require a different fixing method by means of, for example, a top hat section, to prevent the issues with edge distances and fixing proximities at the bracket base.
- Refer to manufacturer's guidance for concrete and timber substrates

5.2.3 Trapezoidal steel weather sheet, pre-coated, fixed to spacer system

Materials for the fasteners are normally coated carbon steel or stainless steel depending upon the system material and the required durability– refer to section 4.1.

a) Primary fasteners / endlaps

Fixed in the valley of the sheet, with a minimum 5.5mm diameter fastener to suit light section steel. A colour-matched integral head is recommended with a minimum 15mm diameter washer for the walls and 19mm for the roof.

b) Secondary fasteners /side laps

Fixed in the crown of the sheet, with a minimum 4.8m diameter stitching fastener. A colour-matched integral head is recommended with a minimum 10mm diameter washer. A low-profile head self-drilling fastener may be preferred is fixing in the crown of a wall sheet.

c) Rooflights

Where rooflights are included refer to section 5.7.

5.3 Composite panels

Factory formed composite panels are available in a wide range of designs; ranging from traditionally through-fixed with exposed fasteners, concealed-fixed through a raised crown, fixed by means of clips and some, particularly flat and low-profile walling panels, are fixed through the concealed joint. It is important, therefore, that the panel supplier's recommendations are followed when selecting fasteners. The through-fixed panels and also those fixed through their raised crown share a common requirement of the fastener design.

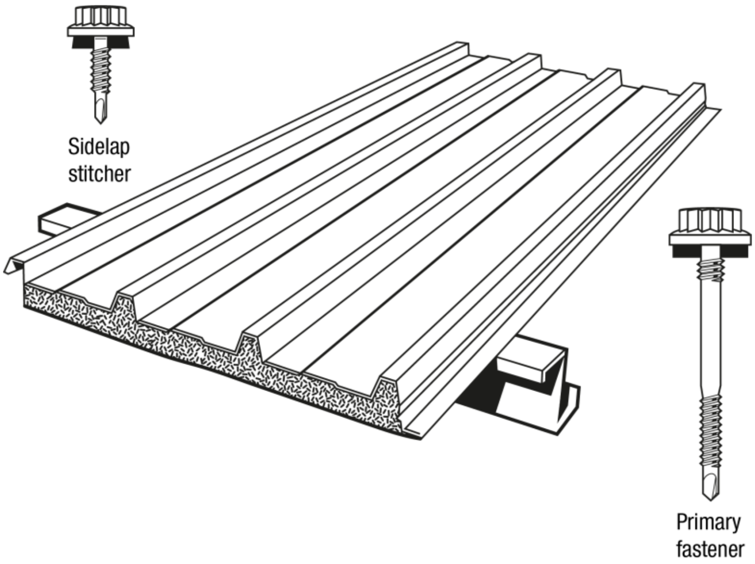

Fig 19: Composite panel construction

5.3.1 Threaded sheet-support

Composite panel type fasteners are dual threaded; the industry-standard 5.5mm (self-driller) or 6.3mm(self-tapper) lower thread fixes into the purlin or rail and a secondary thread of increased diameter is positioned below the head and washer. This upper thread is designed to provide support to the outer metal skin of the panel to ensure that the sealing element of the washer is under permanent compression.

Some composite panel fasteners have a non-threaded section immediately below the head as a means of ensuring washer compression. Fastener suppliers have different designs of top threads, each offering various levels of support to the outer skin of the panel.

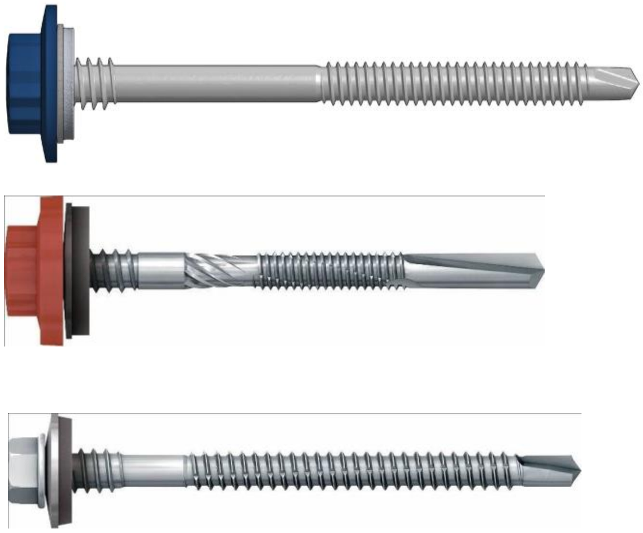

Fig 20: Dual threaded composite panel fasteners

Although there is not, at present, a formal and universally specified test for the performance of this top thread, a test that may be adopted is defined in BS 5427:2016+A1:2017. This is a concentrated load test, or walkability test which simulates the dynamic load, including a safety factor, of a person walking over the sheet. This top thread should withstand such a loading in order to achieve a permanent seal.

5.3.2 Fastener flexibility

A structural load which is associated with fasteners designed for composite panels is a repetitive bending load transmitted to the head of the fastener as a result of panel deflections under wind loadings and general expansion/contraction effects of the panel. This results in the fastener being continually and repetitively bent around the pivot point in the purlin.

The European Assessment Document (EAD) 330047-01-0602 *Fastening screws for sandwich panels* defines in clause 2.2.4 and Annex 4 the repeated bending tests to which composite panel fasteners must be subjected and suppliers should be able to provide guidance on the maximum allowable fastener deflection relative to the panel thickness. These test results should also be published in manufacturers' ETAs where applicable.

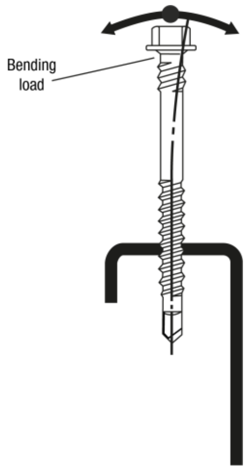

Fig 21: Fastener flexibility

5.3.3 Through-fixed steel faced trapezoidal composite panel, colour coated

Materials for the fasteners are normally coated carbon steel or stainless steel depending upon the system material and the required durability– refer to section 4.1.

a) Primary fasteners / endlaps
Fixed in the valley of the panel, with a minimum 5.5mm diameter lower thread fastener suitable for the substrate being fixed into and having an increased upper thread diameter. A colour-matched integral head is recommended with a minimum 15mm diameter washer for the walls and 19mm for the roof.

b) Secondary fasteners / sidelaps
Fixed in the crown of the sheet, with a minimum 4.8m diameter stitching fastener. A colour-matched integral head is recommended with a minimum 10mm diameter washer. A low-profile head self-drilling fastener may be preferred is fixing in the crown of a wall sheet.

c) Rooflights
Where rooflights are included refer to section 5.7.

As noted above, composite panels have many different jointing and fixing designs, therefore reference must be made to the supplier to ensure appropriate and approved fasteners are selected.

5.4 Secret fix roofing systems

Secret fix roof systems, within the scope of this section, are self-supporting metal profiles, usually either steel or aluminium, with virtually no visible through fixings. Such systems are variously expressed as concealed fixing, standing seam, clip fix, or raised seam. The profiled weathering sheet is usually secured to a clip or halter which is mechanically fixed to the supporting structure, either the purlin or a spacer system as in section 5.2.2.

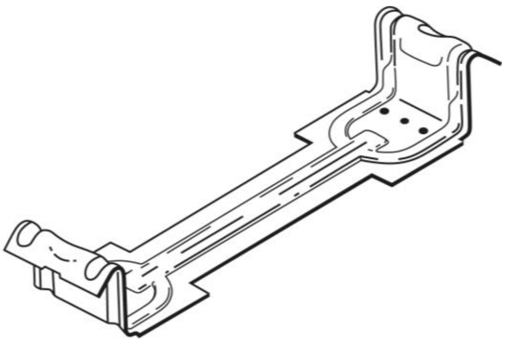

Fig 22: Steel or aluminium clip

Where the system is to be insulated, this is normally achieved with metal liners and insulation. These liners under secret fix systems tend to be of sufficient profile depth and gauge to be walkable and are prefixed to the structure in a similar manner to the equivalent elements of a built-up system with fasteners as described in sections 5.2.1, 5.2.2 and 5.2.3.

A specialist/proprietary fastener is then used to secure the clip/halter. These fasteners provide a specific and vital function to the overall mechanical performance of the system and therefore should always be selected in accordance with the system supplier’s recommendations. Some suppliers actually include this primary fastener within their package when supplying their roofing profiles and clips/halters. The fastener material, headform and thread diameter are usually purpose-selected for the particular secret fix system.

Materials for the fasteners are normally coated carbon steel or stainless steel depending upon the system material and the required durability– refer to section 4.1. Headforms may be the standard hexagon, a flanged hexagon, or a low-profile. Thread diameters may vary from 4.8mm to 6.5mm depending on the required performance and fastener frequency.

Fig 23: Specialist fastener design for secret roof fixing systems

5.5. Built-up constructions on structural metal decks or liners

Section 5.2 described the typical built-up liner panel system which incorporates a non-structural metal liner. This type of liner does not normally form a safe-working platform. Where it is desirable to lay the roofing system off a safe-working platform this can be achieved by increasing the profile strength of the liner.

This method is frequently adopted with the secret fix systems referred to in section 5.4. Fasteners to secure these more structural lining sheets through to the purlins would be the same as in sections 5.2.1, 5.2.2 and 5.2.3.

Structural metal decks offer the designer a further option. These may span between traditional purlins or they may span between the main structural beams, eliminating the need for purlins. The primary fasteners securing the deck to the beam would need to be self-tappers where the total flange and deck thickness exceed 12mm. Due to the long spans, the shear and pull-over capacities of the fasteners and deck would need to be considered to determine the fastener frequency and washer/flange requirement.

Where structural decks are used rather than purlins, the spacing system may be fixed either directly to the deck or, alternatively, to an intermediate section, frequently a metal top-hat shaped profile, which is fixed directly to the deck. Where there is a particular acoustic requirement then acoustic layers may also be positioned within the construction.

As these decks are often between 0.7 and 1.2mm in thickness, traditional threaded fasteners, neither self-drillers or self-tappers as described in sections 3.3 and 3.4, would be considered suitable as there would be too great a risk of overdriving which would seriously reduce the effective performance of this primary fastener and thus put the whole roof system at risk.

For this reason, either a purpose-designed fastener where any effect associated with overdriving can be eliminated, or a 'clamping' fastener ie, a structural rivet should be used. The weatherskin on these systems over structural decks may be the same as with a built-up system whose fasteners are described in section 5.2, or a secret-fix system as described in section 5.4.

5.6 Rooflight systems

Rooflighting within metal roof systems may be in the form of ridge barrel vaults, upslope eaves-to-ridge barrel vaults, pyramid or dome units, or profiled in-plane rooflights. This section will define the fixing requirements for the in plane rooflights. All the other types are usually fixed to a separate kerb or upstand and advice on detailing and fixing should be sought from the relevant supplier.

Rooflights are available in either thermosetting material, GRP, thermoplastic materials, PVC or polycarbonate.

Where there is the requirement for insulated rooflights, they may be either site-assembled or factory assembled. Site-assembled are normally associated with built-up systems (section 5.2) and factory assembled units with composite panels (section 5.3).

Rooflights used in conjunction with secret-fix roof systems (section 5.4) must be selected by reference to the system supplier.

There has been major debate within the metal roofing and cladding industry and, in particular, the rooflight suppliers, on the subject of health and safety and what is a fragile or non-fragile material/construction. This publication is not intended to give specific guidance on health and safety issues. However, tests commissioned by leading in-plane rooflight manufacturers and by the MCRMA have shown that the fastener specification and frequency can play an important part in the impact resistance of the cladding system.

Illustrated below are typical fastener specifications for both site and factory assembled GRP rooflight systems. Fastener spacing depends on the particular rooflight design, material, and loading.

5.6.1 GRP site-assembled liner

a) Primary fasteners / endlaps

Fixed in the valley of the sheet, using a minimum 5.5mm diameter fastener suitable for the substrate being fixed into. Assembled with a 29mm to 32mm diameter washer.

b) Secondary fasteners / sidelaps

Normally a tape as it would not be practical on many lining profiles to mechanically stitch sidelaps

5.6.2 Spacer system fastener

No special extra requirement for site assembled GRP rooflights. Use fasteners as in section 5.2.3.

5.6.3 GRP site-assembled weather skin to spacer system

a) Primary fasteners / endlaps

Fixed in every valley of the GRP sheet or 200mm maximum spacing, with a minimum 5.5mm diameter fastener to suit light section steel. A colour-matched integral head is recommended, usually in a bright colour, for example Poppy Red with a 29mm to 32mm diameter washer.

5.6.4 GRP factory assembled rooflights for through fix composite panel systems

a) Primary fasteners / endlaps

Fixed in every valley of the panel (check with the rooflight supplier), with a minimum 5.5mm diameter lower thread fastener suitable for the substrate being fixed into and having an increased upper thread diameter. A colour-matched integral head is recommended, usually in a bright colour, for example Poppy Red with a 29mm to 32mm diameter washer.

5.6.5 Secondary/side lap fasteners for both site- and factory assembled GRP

a) GRP **over** metal

Fixed in the crown of the sheet, with a minimum 4.8m diameter stitching fastener. A colour-matched integral head usually in a bright colour, for example Poppy Red is recommended with a minimum 14mm to 16mm diameter washer.

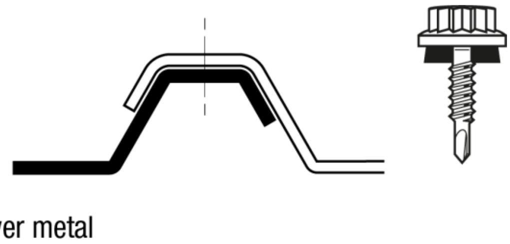

Fig 24 Rooflight side lap stitcher: GRP over metal

b) GRP **under** metal

It is very easy to 'strip' a threaded fastener in GRP, therefore a grommet-type fastener is recommended. These are installed through pre-drilled holes through all of the layers. A colour-matched integral head usually in a bright colour, for example Poppy Red is recommended with a 19mm diameter washer.

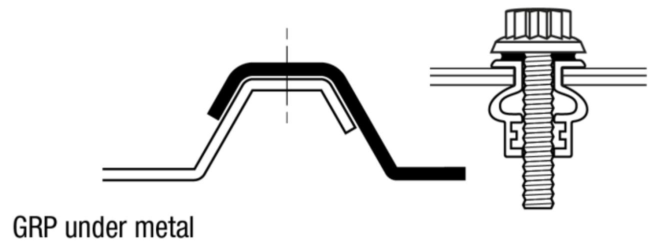

Fig 25 Rooflight side lap stitcher: GRP under metal

Underlap strips – some rooflight manufacturers incorporate a metal underlap strip on the underlapping sidelap crown. This then allows 'standard' self-drilling stitching fastener as in 5.6.5 a) to be used instead of a grommet-type fastener.

5.7 Rainscreen systems

Rainscreen systems are cladding systems applied either during the initial construction of the building or as an over-cladding as part of refurbishment of an existing building. They provide an outer weather resistant layer, fixed to a framing system, in-turn fixed back to the substrate.

This framing system creates a cavity which is ventilated and drained, between itself and the structure. For more detailed guidance, refer to MCRMA guidance documents *GD08 An introductory guide to rainscreen support systems* and *GD11 Fixings and fasteners for rainscreen systems*

6.0 DETAILING

6.1 Fastener effective thread lengths

The 'workable' length of a threaded fastener is referred to as its 'effective-thread-length' (ETL). Threaded fasteners, whether they are the self-drilling or self-tapping type, have a lead-in portion which carries out the drilling and/or threadforming operations. Once correctly installed, this portion of the fastener is redundant or ineffective. The length of this ineffective portion will vary depending upon the type of fastener and its drilling capacity.

Some self-drilling fasteners have an extended un-threaded section between the drill point and the threads to prevent jacking when passing through compressed insulant. This also reduces the effective thread-length. Some fasteners, for example composite panel and some spacer system fasteners (section 5.2.3), are not threaded right up to their head, and therefore there is a minimum, as well as a maximum, effective- thread-length.

When selecting a fastener, the designer/installer must ensure the maximum effective-thread-length of the fastener exceeds the total build-up including the support member. Fastener suppliers should publish data on their products giving details of these effective-thread-lengths.

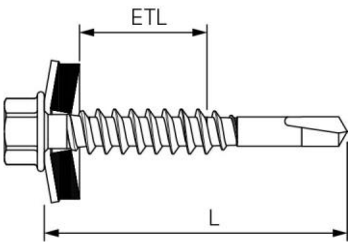

Fig 26 ETL on a fully threaded fastener

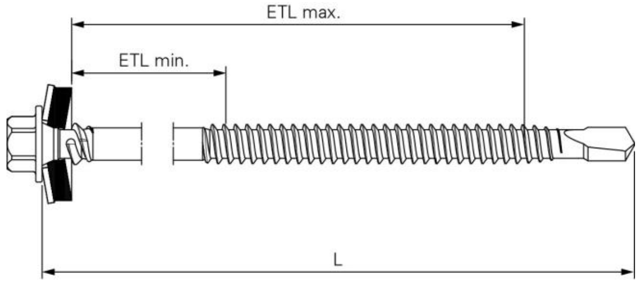

Fig 27 ETL on a dual or partially threaded fastener

6.2 Fastener frequencies

Fasteners, particularly primary fasteners, have to withstand many of the loadings to which the cladding is subjected and transfer them back to the structure. Some of these loadings result in tensile, shear and other forces being transmitted to the fastener, as discussed in section 4.4.

Apart from construction, maintenance, and snow loads, perhaps the most critical load that should be considered in order to determine fastener frequencies is that resulting from wind suction.

The designer, engineer or installer should calculate the wind loads in accordance with specified standards, or other specifications, for example Factory Mutual.
The current UK standard is BS EN 1991-1-4:2005+A1:2010 *UK National Annex to Eurocode 1. Actions on structures. General actions. Wind actions*. Once this load has been determined, the designer, with reference to the fastener and cladding system supplier's data, can ensure that sufficient primary fasteners are specified in order that the relevant safety factors are achieved. With built-up systems, as described in section 5.2, on light gauge purlins, the spacer system fastener frequency may be more critical than the weatherskin or sheet fasteners.

Composite panels, particularly those which have concealed fasteners, typically have fewer fasteners per sheet width than traditional trapezoidal metal profiles, and therefore their frequency should always be checked to ensure it is adequate to withstand the wind loading.

Secret fix systems may transmit other forces on the primary fasteners specific to the particular system, therefore the designer should liaise with the system supplier to ensure all loads have been taken into account.

6.3 Lap configurations

Fasteners are applied through end laps and side laps in profiled metal cladding, depending upon the system being used. Frequently these laps also contain weatherseals. The position of the fastener relative to the profile and seals is often critical. For indicative guidance on endlaps and sealants please refer to *GD19 Effective sealing of end lap details in metal roofing constructions*.

6.4 Thermal movement

Even though metal cladding profiles are defined in BS 5427:2016+A1:2017 as 'flexible', materials which have a high coefficient of thermal expansion may require special provisions at fixings.

For example, aluminium, which has twice the thermal coefficient of expansion of steel, may require a special end lap detail, depending on the sheet length and colour, to ensure the fastener facilitates the expansion. The designer should liaise with the system supplier to ensure their recommendations are followed.

Other materials incorporated within metal cladding systems may also require special provisions to accommodate thermal movement. PVC and polycarbonate require pre-drilled oversize holes at fixing positions. The designer should liaise with the system supplier to ensure their recommendations are followed. See also section 6.6 Flashings and Fabrications.

6.5 Thermal bridging

On built-up metal systems, fasteners would not be considered as contributing to any significant thermal bridging effect. Spacing systems are normally designed with thermal breaks and their effect on the overall thermal transmittance through the roof is normally taken into account when selecting insulation types and thicknesses.
On through-fix composite panels with properly sealed and insulated joints, the only potential for thermal bridging is via the primary fasteners. In practical terms, in the UK environment the effect of fasteners is usually negligible. Refer to MCRMA guidance document *GD26A Aluminium fabrications and flashings: interim guidance*.

However, if all environmental conditions, including both external and internal temperatures and relative humidities are notified, a qualified assessment by the engineer or panel supplier of the effect of the carbon or stainless steel fasteners on the thermal performance of the panel may be made.

It should be noted that the thermal conductivity of stainless steel is approximately 60 percent of the thermal conductivity of carbon steel and therefore creates a smaller thermal bridge. Refer to MCRMA guidance document *GD26A Aluminium fabrications and flashings: interim guidance.*

6.6 Flashings and fabrications

Guidance document *GD 26 Aluminium fabrications and flashings: best practice design and fixing guide* is currently under review. This guidance document addresses the effects of thermal movement in aluminium fabrications and flashings and give suggestions on methods of fixing to accommodate thermal movement.

For the latest advice please refer to guidance document GD 26A *Aluminium fabrications and flashings – interim guidance.* MCRMA intends to re-publish guidance document GD 26 on the design and installation of aluminium fabrications once the research is complete. This will be published via the MCRMA website.

6.7 Corrugated profiles

Corrugated or sinusoidal metal profiles, including the industry standard '3 inch' profile as defined within BS 3083:1988 *Specification for hot-dip zinc coated and hot-dip aluminium/zinc coated corrugated steel sheets for general purposes,* would normally be primary fastened through their crowns to permit free drainage when used in a roofing application.

To ensure a seal against the curved metal surface, specially shaped saddle or sealing washers should be included. Corrugated metal profiles for walling applications may be valley fixed providing the sealing element is designed and shaped to ensure a seal against the curved valley profile.

6.8 Fixing to timber

BS EN 1995-1-1 +A2 gives guidance on the structural use of timber including where fasteners are required to provide integrity to the timber structure. The timber fastener connections should be designed in such a way that the edge distances and fastener spacings as defined in the standard and shown in the standard are complied with.

Where threaded fasteners are used for primary purposes to secure metal cladding profiles , or other structural components such as spacer systems, back to the structural timber supports and where they are not required to provide the integrity of the structural timber then Table 5 below can be used as a general guide for securing the metal cladding elements back to the timber.

Spacing	With self-drilled or pre-drilled holes
End distance parallel to grain	10*d*
Edge distance perpendicular to the grain	4*d*
Distance between lines of fasteners, perpendicular to the grain	*5d*
Distance between adjacent fasteners in any one line, parallel to the grain	*7d*
Note: *d* is the outer shank diameter of the fastener	

Table 4: Minimum fastener spacings

Primary fasteners for securing profiled metal cladding to timber supports are typically a minimum of 5.5mm diameter, often with a 'gimlet' type point to facilitate the piercing of the metal.

Where standard self-tappers as shown in section 3.4 are used, it is recommended the timber (and metal) is pre-drilled with a small diameter pilot hole in order to release stresses in the timber and prevent splitting. To provide the required pull-out resistance of a fastener into timber supports, there must be an adequate thread penetration depth - 35mm is the minimum for most applications however, calculations should be made for verification purposes.

6.9 Firewalls

Most metal cladding manufacturers have tested their systems and can provide firewall systems with ratings up to 4 hours (more than 1m from the boundary). System suppliers must be consulted to establish any specific fastener requirements over and above the typical arrangements shown under section 5.0.
Where a built-up system includes a mini-zed and ferrule spacer system, as described in section 5.2.3, the ferrules must be made from steel, and not plastics, as is the case in some manufacturers' firewall systems.

It may also be a typical requirement to stitch the lining laps/side joint on both composite and built-up systems. This may be either a threaded stitching fastener or a rivet, depending on the system, but the fastener material must be carbon or stainless steel and not aluminium. In all instances where a firewall is required, the designer should liaise with the system supplier to ensure their recommendations are followed.

6.10 Material compatibility

The risk of bi-metallic corrosion between components of different metals should be assessed by the designer. PD 6484:1979 *Commentary on corrosion at bi-metallic contacts and its alleviation*, may be referred to in order that any risk can be assessed. Consideration must be made to the relative surface areas of the metals in contact and the moisture content of the environment.

To prevent bi-metallic corrosion at the connection, the fastener should be of a material with, at least, the equivalent corrosion resistance to the material being fastened into/through. For these reasons, stainless steel fasteners are considered the recommended choice for securing aluminium profiles to galvanised steel or aluminium support sections, whereas carbon steel fasteners in the same application would be at risk of accelerated corrosion.

Perhaps the main risk within metal cladding systems occurs where aluminium profiles are in contact with galvanised steel spacers or supports. It is recommended practice therefore, in these conditions to apply a separation layer, usually an adhesive barrier tape, over the whole surface of the support component in contact with the aluminium.

Additionally, a stainless fastener used to fix a pre-coated steel sheet into a galvanised spacer system or purlin/rail would not be considered to present a bimetallic corrosion risk to the steel sheet or purlin/rail.

6.11 Swimming pools

Roofing and cladding fasteners for envelopes over swimming pools require special consideration. Austenitic stainless steels of grades EN1.4301 [A2 or 304] and EN1.4401 [A4 or 316] have been shown over many years to be reliable and corrosion resistant in most roofing applications, including swimming pools, where good design, detailing, installation and effective air handling/maintenance systems minimise the corrosion effects of the environment.

However, in certain localised conditions, where high humidity and chlorine-rich conditions apply and condensation has been allowed to form, components from these grades can be subject to a particular form of corrosion, known as Stress Corrosion Cracking (SCC) that may cause sudden, unexpected failures leading to the potential detachment and collapse of building elements within the poolhall putting lives at risk.

This is now a well-documented problem, identified by pool experts, the Nickel Development Institute (NDI), Health and Safety and the Steel Construction Institute (SCI), which extends to many EN1.4301 and EN1.4401 components, for example twisted wire ropes, nuts, bolts and other fasteners, which when exposed to condensation risk within pool halls can lead to SCC. It is therefore recommended these grades of stainless are not used for components in a ‘safety critical’ application.

Where roofing/cladding fasteners of these grades are installed above, and without penetrating, an effective vapour barrier as part of a roofing/ cladding system, they can generally be considered to be ‘non-safety critical’ – regarding the risk of SCC.

The vapour barrier needs to be designed and installed to ensure its effectiveness throughout the life of the roofing /cladding system and careful detailing, installation and sealing of the vapour barrier at all junctions and penetrations is required to maintain the “non-safety critical” status above the vapour barrier. Where fasteners penetrate or are below the vapour barrier, the fastener manufacturer should be consulted.

The design of heating and air conditioning systems and their effective use and maintenance can help to minimise the condensation risk and conditions that promote SCC. This is especially important in fun and leisure pools where waterfalls, wave machines and saunas can contribute to the humidity levels.

Where roofing/cladding fasteners need to be used in ‘safety-critical’ applications and are not protected by the vapour barrier, then special high molybdenum (6-7%) austenitic grades such as EN 1.4529 and EN 1.4547 are now recommended by pool experts and the Institutes noted above. A limited range of fasteners, generally self-tappers, is available in these grades from some manufacturers/suppliers so it is recommended they be consulted at an early stage of the project.

6.12 Fastener penetrations

The client/designer may find it desirable, either for safety or aesthetic reasons, to minimise the length or protect the portion of fastener visibly protruding on the underside of the supporting structure. Push-fit screw tip caps may provide an acceptable solution.

In applications where the protruding length is required to be reduced then this should only be considered where the supporting element is of a thickness such that the pull-out performance of the fastener, in practical terms, will not be adversely affected. Typically, this would only apply to hot-rolled steel of at least 6mm thickness and not to cold-rolled sections and decking applications.

The method of reducing the penetration length should not transmit any tensile forces to the fastener and grinding or cropping may be considered. Where applicable, any corrosion protection to the fastener should be reinstated. Consult the fastener manufacturer/supplier as this may invalidate any warranty that may have been expected or given.

7.0 INSTALLATION AND TOOLING

Precision engineered fasteners require compatible tools to optimise installation time and quality. Screw guns are an installer essential when working in roofing and cladding construction, as they ensure that the optimum mechanical performance of a self-drilling fastener is obtained, guaranteeing the integrity of the building envelope.

IN SUMMARY

Do

- Install roofing and cladding self-drilling fasteners using either a battery screw gun or a 110v screw gun.
- Ensure that the screw gun is fitted with a correctly adjusted depth locating nose piece (unless the fastener has features to prevent overdriving)
- Install roofing and cladding self-drilling fasteners at speeds less than 2000 rpm.
- Always use the correct PPE to avoid personal injury.
- Ensure correct sockets and drive bits are used.
- Any magnet must be recessed deep enough to clear the head.
- External sockets must drive on the flange at the base of the screw head.

Do not

- Install roofing and cladding fasteners with either an impact driver or a dry wall screw gun.
- Apply excessive end loads (bodyweight force) via the screw gun whilst the fastener is drilling, particularly on thicker hot rolled/heavy section steel supports.

Please refer to MCRMA guidance document *GD32 Self drilling fastener installation tools*

MCRMA member companies provide a wide range of building envelope solutions for metal-based roofing and cladding products and services and they can advise on the suitability and performance of materials, systems and assemblies.

Manufacturers are best placed to offer advice about their particular products and any variation from their published data during the design or construction process could result in the component or system failing prematurely or not complying with the guarantee or warranty conditions. In addition, design information can be obtained from any of the independent roofing and cladding inspectors featured on the MCRMA web site.

8.0 REFERENCES

British Standards

BS 3083:1988 *Specification for hot-dip zinc coated and hot-dip aluminium/zinc coated corrugated steel sheets for general purposes*

BS 5427:2016+A1:2017 Code of practice for the use of profiled sheet for roof and wall cladding on buildings

BS 7543:2015 *Guide to durability of buildings and building elements, products and components*

BS 8539:2012 *Code of practice for the selection and installation of post-installed anchors in concrete and masonry*

BS EN 1993-1-3:2006 Eurocode 3 *Design of steel structures. General rules. Supplementary rules for cold-formed members and sheeting*

BS EN 1995-1-1:2004 + A2:2014 Eurocode 5 *Design of timber structures. General rules. Common rules and rules for buildings*

BS EN ISO 12944-2:2018 *Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Classification of environments*

NA to BS EN 1991-1-4:2005+A1:2010 *UK National Annex to Eurocode 1. Actions on structures. General actions. Wind actions*

MCRMA publications

Guidance document GD08 *An introductory guide to rainscreen support systems*

Guidance document GD11 *Fixings and fastenings for rainscreen systems*

Guidance document GD19 *Effective sealing of end lap details in metal roofing constructions*

Guidance document GD26A *Aluminium fabrications and flashings: interim guidance*

Guidance document GD32 *Self drilling fastener installation tools*

Technical paper No 3 *Secret fix roofing design guide*

Technical paper No 5 *Metal wall cladding design guide*

Technical paper No 6 *Profiled metal roofing design guide*

Other publications

European Assessment Document (EAD) 330047-01-0602 – *Fastening screws for sandwich panels*

HSG 33 *Health and Safety in roof work*

Nickel Development Institute *NDI Stainless steel in swimming pool buildings*

NFRC *Profiled sheet metal for roofing and cladding. A guide to good practice*

PD 6484:1979 Commentary on corrosion at bi–metallic contacts and its alleviation

ACKNOWLEDGEMENT

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