




NZ METAL ROOF AND WALL CLADDING

# CODE OF PRACTICE

**VERSION 3.0 / February 2019**

MRM
NZ METAL ROOFING MANUFACTURERS INC.

# NZ Metal Roof And Wall Cladding Code Of Practice v3.0

# 1 Introduction

The NZ Metal Roof and Wall Cladding Code of Practice (COP) is published by NZ Metal Roofing Manufacturers Inc. (MRM), to provide:

- acceptable trade practice for the fixing of metal roof and wall cladding and accessories.
- prescriptive detailing for designers and sets a benchmark for the standard of detailing and workmanship required over and above that required to comply with the NZBC.

The COP does not describe or dismiss alternative methods, which may need specific acceptance by the Building Consent Authorities.

It is published in accordance with current technology, materials, and building codes. The COP will be periodically updated to reflect changes in legislation and standards or improvements in technology and available materials.

The most current Code of Practice is available on the MRM website, www.metalroofing.org.nz/cop, as *Code of Practice Online* (MRM COP Version 3).

The most recent Update to the COP was on 1 February 2019.

In this update, no recommendations have been altered that would require changes to existing projects in progress.

**Summary of Changes in this Update**

- Two new clauses were added in 3 *Structure* to discuss 3.13 Material Grade and 3.14 Material Thickness.
- Two new, separate, clauses under 4.16 Clearances, discuss 4.16.1 Ground Clearance and related 4.16.2 Site Management in more detail.
- Clauses dealing with 3.12.1 Screw Fasteners fixing to specific purlin types re-ordered for clarity.
- New drawing to show recommended 9.4A Penetration Type at Recommended Position.
- Other updates consist of Category 1 – minor errata corrections to spelling, and grammar and layout.

See 19.1 2019 – February for details of the changes in this Update.

## 1.1 Disclaimer and Copyright

Although the information contained in this Code has been obtained from sources believed to be reliable, New Zealand Metal Roofing Manufacturers Inc. makes no warranties or representations of any kind (express or implied) regarding the accuracy, adequacy, currency or completeness of the information, or that it is suitable for the intended use.

Compliance with this Code does not guarantee immunity from breach of any statutory requirements, the New Zealand Building Code or relevant Standards. The final responsibility for the correct design and specification rests with the designer and for its satisfactory execution with the contractor.

While most data have been compiled from case histories, trade experience and testing, small changes in the environment can produce marked differences in performance. The decision to use a particular material, and in what manner, is made at your own risk. The use of a particular material and method may, therefore, need to be modified to its intended end use and environment.

New Zealand Metal Roofing Manufacturers Inc., its directors, officers or employees shall not be responsible for any direct, indirect or special loss or damage arising from, as a consequence of, use of or reliance upon any information contained in this Code.

New Zealand Metal Roofing Manufacturers Inc. expressly disclaims any liability which is based on or arises out of the information or any errors, omissions or misstatements.

If reprinted, reproduced or used in any form, the New Zealand Metal Roofing Manufacturers Inc. (NZMRM) should be acknowledged as the source of information.

This is the current online Code of Practice, published in December 2017.

- Sections marked as Version 3.0 contains new, substantially updated information and interactive tools.
- Sections marked as V2.3 denotes a revised edition of V2.2 (published in November 2012)

New Zealand Metal Roofing Manufacturers Inc. (NZMRM) periodically updates the information contained in this Code.

Before using this Code, please refer to the New Zealand Metal Roofing Manufacturers Inc. website (**www.metalroofing.org.nz**) for the most recent updates on information contained in this Code.

# 1.2 Scope

This Code of Practice provides requirements, information and guidelines, to the Building Consent Authorities, the Building Certifier, Specifier, Designer, Licensed Building Practitioner, Trade Trainee, Installer and the end user on the design, installation, performance, and transportation of all metal roof and wall cladding used in New Zealand.

The calculations and the details contained in this Code of Practice provide a means of complying with the performance provisions of the NZBC and the requirements of the Health and Safety at Work Act 2015.

The scope of this document includes all buildings covered by NZS 3604, AS/NZS 1170 and those designed and built under specific engineering design.

It has been written and compiled from proven performance and cites a standard of acceptable practice agreed between manufacturers and roofing contractors.

The drawings and requirements contained in this Code illustrate acceptable trade practice, but recommended or better trade practice is also quoted as being a preferred alternative.

Because the environment and wind categories vary throughout New Zealand, acceptable trade practice must be altered accordingly; in severe environments and high wind design load categories, the requirements of the NZBC will only be met by using specific detailing as described in this Code.

The purpose of this Code of Practice is to present both Acceptable Trade Practice and Recommended Trade Practice, in a user-friendly format to ensure that the roof and wall cladding, flashings, drainage accessories, and fastenings will:

- comply with the requirements of B1, B2, E1 E2 and E3 of the NZBC;
- comply with the design loading requirements of AS/NZS 1170 and NZS 3604 and with AS/NZS 1562;
- have and optimised lifespan; and
- be weathertight.

# 1.3 Related Documents

## 1.3A

| Standard | Year | Title |
|---|---|---|
| **NZ 2295** | 2017 | Pliable, permeable building underlays. (either NZS 2295 2017 or NZS 2295 Amendment 1 2017) |
| **NZS 3602** | 2003 | Timber and wood based products for use in building. |
| **NZS 3603** | 1993 | Amendment 4 2005 Timber Structures Standard. |
| **NZS 3604** | 2011 | Timber Framed Buildings. |
| **AS/NZS 1170.0** | 2002 | Amendment 5 2011 Structural design actions. General Principles. Commentary to Parts 0, 1 and 2. |
| **AS/NZS 1170.1** | 2002 | Amendment 2 2009 Structural design actions. Permanent, imposed and other actions. |
| **AS/NZS 1170.2** | 2011 | Amendment 4 2016. Structural design actions. Wind Actions. |
| **AS/NZS 1170.3** | 2013 | Amendment 1 2007 Structural design actions. Snow and ice actions |
| **AS 1562.1** | 1992 | Design and Installation of sheet roof and wall cladding – Part 1 Metal |
| **AS 1562.3** | 2006 | Design and Installation of sheet roof and wall cladding – Part 3 Plastic (was AS/NZS 1562.3 1996) |
| **AS/NZS 1734** | 1997 | Aluminium and aluminium alloys - Flat sheet, coiled sheet and plate |
| **AS/NZS 2728** | 2013 | Prefinished/prepainted sheet metal products for interior/exterior building applications—Performance requirements |
| **AS/NZS 4257** | 1994/97 | Plastic roof and wall cladding materials. Parts 0-9 Methods of Test. |
| **AS/NZS 4389** | 2015 | Roof Safety Mesh. |
| **AS/NZS 4600** | 2005 | Amendment 1 2010. Cold-formed Steel Structures. |
| **AS 1391** | 2007 | (R2017) Metallic materials - Tensile testing at ambient temperature |
| **AS 1397** | 2012 | Continuous hot-dip metallic coated steel sheet and strip - Coatings of zinc and zinc alloyed with aluminium and magnesium |
| **AS 3566.1** | 2002 | 1. General requirements and mechanical properties |
| **AS 3566.2** | 2002 | 2. Corrosion resistance requirements. (Withdrawn) |
| **AS 4256** | 2006 | Plastic roof and wall cladding materials. (Now AS only previously AS/NZS 4256 1994). Parts 1-5. Plastic materials. |
| **BS 1470** | 1987 | Specification for wrought aluminium and aluminium alloys for general engineering purposes. (Replaced by 9 EN Standards) See AS 1734 |
| **BS 2870** | 1980 | Specification for rolled copper and copper alloys. (Replaced by EN standards) |
| **BS EN 988** | 1987 | and BS EN 1179 2003 Specification for zinc alloy sheet and strip |
| **ISO 9223** | 2012 | Corrosion of metals and alloys. Corrosivity of atmospheres - Classification. |
| **ISO 9224** | 2012 | Corrosion of metals and alloys. Corrosivity of atmospheres - Guiding values for the corrosion categories. |

| Standard | Year | Title |
|---|---|---|
| **ISO 9225** | 2012 | Corrosion of metals and alloys -- Corrosivity of atmospheres -- Measurement of environmental parameters affecting corosivity of sites |
| **ISO 9226** | 2012 | Corrosion of metals and alloys -- Corrosivity of atmospheres -- Determination of corrosion rate of standard specimens |
| | | |
| **AS/NZS 3500.3** | 2015 | Stormwater drainage |
| **AS/NZS 2179.1** | 2014 | Metal shape or sheet rainwater goods, and metal accessories and fasteners |
| **AS 2180** | 1986 | Metal rainwater goods - Selection and installation |
| **HB 114** | 1998 | Guidelines for design of eaves and box gutters |
| | | |
| **AS 4312** | 2008 | Atmospheric corrosivity zones in Australia |
| **HB 39** | 2015 | Installation code for metal roofing and wall cladding |
| **AS/NZS 2312** | 2002 | Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings |
| | | |
| **AS 4040.0** | 1998 | Methods of testing sheet roof and wall cladding Introduction, list of methods and general requirements |
| **AS 4040.1** | 1998 | Methods of testing sheet roof and wall cladding Resistance to concentrated loads |
| **AS 4040.2** | 1998 | Methods of testing sheet roof and wall cladding Resistance to wind pressures for non-cyclone regions |
| **AS/NZS 4200.1** | 2017 | Pliable building membranes Part 1: Materials |
| **AS 4200.2** | 2017 | Pliable building membranes Part 2: Installation |

## 1.4 Acknowledgements

The MRM Technical Committee continuously update this COP, which was originally authored by Stuart Thomson.

Our thanks to advisors, designers and trades people for their input.

## 1.5 Disputes

Under the provisions of the Building Act and the NZBC, a contractor who undertakes to do work on a building implies that he can produce an effective and sound result which will fulfil its intended purpose.

There is a customer expectation, backed by consumer legislation, that the finished work will leave the building weathertight, and the work done will comply with the NZBC and will be to a standard that is described as “acceptable trade practice”.

“Acceptable trade practice” and “good trade practice” for the Roofing Industry are both described and contained in this Code of Practice. In addition to any contractual or verbal offer there may also be a written obligation given in the form of a warranty. See 16.9 Material Selection

All contractors should ensure that materials they use comply with the requirements and specifications contained within this Code of Practice. All suppliers’ or manufacturers’ product literature should be dated; and where superseding previous literature the dates should be referenced. The user must ensure that suppliers or manufacturers product literature is the latest version published.

Contractors must be satisfied that the product as described in the product literature is acceptable to the Territorial Authority, and contractors must be aware of their liability under law and the contractual documents they have signed or agreed to.

Customer expectation is supported by law that states that the material and product used must be fit for its intended purpose, and the liability of each of the parties is assessed on their ‘failure to warn that the product would not fulfil a perceived function".

Poor workmanship is a common cause of dispute and it is often given as the reason for non-payment between the sub-contractor and contractor or owner. This Code of Practice provides a standard of workmanship and a benchmark for arbitration.

It is in the interest of all parties to avoid the cost and delay of litigation and although there are other voluntary ways to settle disputes, they all require some compromise by those concerned.

One voluntary method is negotiation by calling a site meeting where all interested parties can air their grievances across a table and draw up a programme of rectification and reach an agreement over responsibilities and payment.

Any agreement must be recorded, signed and state what is to be done, how much is to be paid, by whom, by when, and how it will be accepted and checked. If no agreement can be reached then a solution may be found through mediation.

The Weathertight Homes Resolution Services Act 2006 provides for a mediation service to be available to dwelling/house owners with eligible claims. The claiming owner and any of the other parties against whom the claim is made may agree to refer the claim to mediation, with provision for binding settlements by agreement. This service is restricted to leaky homes built within 10 years of the claim.

### 1.5.1 Mediation

Mediation is a cost-effective, confidential, and voluntary process where the mediator is the facilitator who assists the parties to come to a negotiated agreement. Mediation concentrates on the parties' interests rather than on their rights, when often both parties realise that they are partly at fault and wish to resolve the dispute and accept a compromise, as opposed to litigation. Any recorded settlement in a mediation agreement can be enforced as a contract, but if they cannot reach a settlement, they can refer to arbitration or the courts.

A mediator acceptable to all parties is appointed and he should act independently, avoid unnecessary expense and comply with the principles of natural justice. The mediator's task is to help the parties identify the issues and options for settlement and look for a settlement that is equitable to all concerned. All relevant documents including specifications, plans, quotations, and written submissions setting out the basis of the complaint and the rebuttal by the other party must be made available to the mediator.

After an investigation, site visits, and discussion with all the parties, the mediator, using trade benchmarks such as this Code of Practice and drawing on his experience can apportion responsibilities and instruct rectification work be done. This method can provide a quick and inexpensive outcome with costs shared by both parties, but the decision is not binding and must be mutually agreed to.

Informal resolution of disputes does not necessarily uncover the facts; and as material or installation failures are not necessarily publicly disclosed, improvement can be inhibited.

Mediation does provide the opportunity to 'move on' and does not always jeopardize business relationships as litigation invariably does.

## 1.5.2
## Adjudication

The Construction Contracts Act provides for a process of dispute resolution called adjudication, to be the first option if negotiation fails. It provides a thirty-day formal process whereby the adjudicator is appointed by the claimant, and the respondent cannot opt out. The process is designed mainly for payment disputes, but it can also be used for workmanship disputes and is expected to become the normal dispute resolution method in the Construction Industry.

The adjudicator's decision, called a determination, is binding and enforceable by the courts. An unsatisfied party can only appeal an adjudication after complying with the determination. The adjudication is subject to confidentiality, except by mutual consent or if the information is already in the public domain.

The disadvantage of both mediation and adjudication is that the faults are not made known to the roofing industry, who should be able to learn from the mistakes of the past.

Where the amount in question is under $7,500, or $12,000 by agreement with the other party, an alternative method is to file the complaint with the Disputes Tribunal. The parties usually represent themselves, without lawyers, and a compromise outcome is sought by a referee. This method of settlement gives no assurance of an equitable outcome or that the outcome will be based on technical grounds; the main purpose of this court is to seek agreement between the parties.

## 1.5.3
## Arbitration and Litigation

Arbitration is usually a strict and formal process similar to litigation in which the parties may be legally represented and select and pay for the arbitrator. Arbitrators must comply with the Arbitration Act; their imposed decision is known as an award, and it is final and binding.

The final and expensive alternative is litigation. That usually involves suing for breach of contract, non-payment, non- performance, faulty materials, or non-compliance. Judgment is publicly imposed and usually made by comparison with “state of the art” materials and practice available at the time the contract was signed.

Both arbitration and litigation can be prolonged and the parties’ cost may exceed the amount in dispute.

When the roofing contractor sublets his contract, he assumes the same responsibility as though he carried out the work himself.

To avoid disputes, roofing suppliers and contractors must give adequate instruction, training, and supervision. They should also keep their staff informed of industry developments and with the contents of the New Zealand Metal Roof and Wall Cladding Code of Practice.

# 2 Glossary

The glossary section provides definitions and descriptions of commonly used terms, as well as illustrations of domestic cladding terminology, industrial cladding terminology, and profile geometry.

# 2.1 Definitions

The glossary provides a list of definitions for commonly used terms in the roof and wall cladding industry.

## 2.1A Definitions

| | | |
|---|---|---|
| **Absorption** | The ability of a material to accept liquid within its body. | |
| **Acceptable solution** | A prescriptive means of compliance with the performance requirements of the NZBC, approved by the Ministry of Business, Innovation and Employment. | |
| **Acceptable trade practice** | The minimum standard of design and workmanship to comply with the performance requirements of the NZBC. | |
| **Accessories** | Gutters, ridge capping, ventilators, flashings, downpipes, brackets and their fixings. | |
| **Action-effect** | A force due to a load. | |
| **Acute angle** | An angle that is less than 90° | |
| **Alloy** | A metallic substance composed of two or more chemical elements, at least one of which is a metal, combined to give enhanced strength, resistance to corrosion or lower the melting point. | |
| **Aluminium/zinc** | A continuously hot-dipped coating used to protect steel against corrosion, commonly consisting of 45% zinc and 55% aluminium by mass, generally conforming to AS/NZS 1397. | AZ; Zincalume®; Galvalume; Aluzinc; Duralume |
| **Anneal** | Softening a metal by heating, to restore or increase its ductility. | |
| **Annular grooved nail** | A nail having a shank deformed with a series of circular grooves. | |
| **Anodic** | Galvanic corrosion can occur when two metals are connected in moist or wet conditions. The anodic metal, being more active (-), sacrifices itself to protect the more noble metal in the galvanic series, cathodic (+). | |
| **Applied finish** | A surface finish applied to metal tiles, shakes, or accessories subsequent to pressing or forming. | Post-form painting |
| **Approved** | Any documentation, solution or method that is accepted by a recognised authority. | |
| **Apron** | A near horizontal flashing with a vertical upstand that covers the intersection between a vertical and a horizontal or sloping surface. It can run across the roof profile (transverse) or in the same direction (longitudinal) and prevents water ingress or sheds water from a higher wall or roof onto a lower roof. | Abutment flashing |
| **Astragal** | A metal strap used to fasten downpipes to a wall. | Standoff bracket |
| **Asymmetrical profile** | A profile that has a different configuration on opposite sides of the horizontal centre axis. The opposite to symmetrical. | |

| | | | |
|---|---|---|---|
| **Average Recurrence Interval** | ARI | The rainfall intensity in New Zealand is determined by the rainfall during a ten minute period, measured in millimetres per hour.<br><br>The ARI represents the expected timespan between exceedances of a given rainfall intensity. | |
| **Awning** | | A roof projecting from a building, usually open on three sides. | Canopy |
| **Baby Iron** | | A miniature corrugated profile rolled with 6 mm high ribs. | Sparrow iron; mini-corrugate; and mini-iron |
| **Backer coat** | | An organic coating on the reverse side of a pre-painted strip or coil, not intended for external exposure. | |
| **Back-out** | | The condition when a fastener works loose due to timber shrinkage, thermal movement, vibration or an incorrect thread type. | |
| **Barge flashing** | | A flashing covering the intersection of a roof surface and a lower vertical surface or covering the intersection of a roof surface and a lower vertical surface. | Barge roll; cover roll; ridge roll; barge mould; square barge |
| **Base metal thickness** | B.M.T. | The thickness of the bare or base metal before any subsequent coating. | Gauge |
| **Battens** | | A narrow timber, steel or polystyrene member attached to a roof or wall structure, used to attach metal cladding, metal tiles, shakes or shingles to the structure. It can also function as a spacer. | |
| **Bay** | | A wide pan of fully supported roof cladding laid between standing seams or rolls. | |
| **Bead** | | (a) A curled stiffening to a metal edge<br>(b) A rounded strip of sealant.<br>(c) A ball-shaped piece of solder or brazing. | |
| **Bend radius** | | The formed outside radius on a flashing or sheeting. | |
| **Blind Rivet** | | A small headed hollow tubular fastener with an expandable body for joining sheet metal; capable of being fastened from one side. | Rivet. |
| **Boot flashing** | | A proprietary EPDM prefabricated flashing used to weatherproof circular pipes protruding from a roof or wall. | |
| **Bossing** | | The working of a malleable metal into a required shape, using wooden or plastic tools. | Dressing |
| **Box gutter** | | (a) A square or rectangular internal gutter between two roof surfaces or at a parapet wall.<br>(b) A square profile spouting attached to an external wall or fascia. | |
| **Brazing** | | The joining of metals using an alloy with a lower melting temperature than either of the metals to be joined. | |
| **Brittle roofing** | | Flat, troughed or corrugated plastic, asbestos, or other sheeting that is or can become brittle. | |
| **Broken bond** | | Tiles laid so that the side laps of any two adjacent rows of tiles down a roof do not line up and are staggered or offset. | |

| | | | |
|---|---|---|---|
| **Buckling** | | A loss of the original shape of metal, by compressive bending, bearing or shear loading. | kink; ding; wrinkle; bulge |
| **Building Consent Authority** | BCA | A Building Consent Authority accredited by the Ministry of Business, Innovation and Employment (MBIE) to issue building consents. BCAs are usually local and district councils, but they can also be regional councils (for dams) and private organisations. | |
| **Building Insulation Blanket** | BIB | Lightweight, flexible bulk insulation that is supplied in a continuous roll. | |
| | F.F.B.I.B. | Building insulation blanket faced with foil. | |
| **Building paper** | | An absorbent permeable membrane made from treated kraft paper, placed under roof or wall cladding. | permeable roofing underlay |
| **Bullnose** | | A shaped piece of roof cladding, curved near to a quarter circle on its outer end, and used predominately as veranda roof sheeting. | |
| **Butt strap** | | A soaker under flashing, used as an expansion joint. | |
| **Butterfly roof** | | A structure having two inward sloping roofs, draining to an internal gutter. | |
| **Camber** | | (a) The deviation from a straight line of a side edge of metal cladding, flashing or unformed coil.<br>(b) A slight convex curve of a surface, such as in a roof deck.<br>(c) A load induced curve, or a pre-induced curve to counter the effect of a member bending under load. | |
| **Canopy** | | A cantilevered roof without walls over a doorway. | awning |
| **Canterbury prickle** | | A small shaped capping to a roof rib at a change of pitch. | ribcap |
| **Capillary** | | The action that causes movement of moisture between two surfaces in close contact. | capillary action; capillary attraction; wicking. |
| **Capillary groove** | | An indentation formed in the edge of a metal cladding profile or flashing to prevent capillary action. | capillary barrier; anti-capillary edge |
| **Capping** | | The top flashing of a wall, parapet or balustrade. | coping |
| **Cat ladder** | | A ladder fixed vertically to a wall, or used on a steep pitched roof as a temporary means of access. | roof ladder |
| **Catchment** | | The roof or roof and wall area above a gutter, valley, or penetration that will collect rainwater. | |
| **Cathedral roof** | | A roof having a pitch over 45°. | |
| **Cathodic protection** | | The protection of one metal by another by the more active (Anodic) metal reacting with the elements in preference to the other | sacrificial protection |
| **Cavity construction** | | A roof or wall construction that provides a drained air gap separation from the external cladding. | |
| **Chalking** | | The result of weathering on an organic paint film, the degradation of which produces a chalky surface layer. | |

| | | | |
|---|---|---|---|
| **Chase** | | A groove or recess cut into a concrete or block wall to accommodate a flashing. | |
| **Chord** | | (a) The horizontal member (bottom chord) or a pitched member (top chord) of a truss.<br>(b) A straight line drawn across a circle with each end touching the circumference. | |
| **Cladding** | | Roof sheeting fixed to the roof structure, or wall sheeting fixed to walls as the weather-resistant surface of a building. | |
| **Cleat** | | A continuous concealed clip without external fixings used to fasten roof cladding or flashings. | |
| **Clerestory roof** | | A roof covering of a high vertical window between two opposing roof planes of different heights, used for borrowed light or ventilation. | |
| **Clip** | | A small fixing used to secure roof cladding, flashings or pipes to the structure. | |
| **Closure strip** | | A metal or plastic flashing, blocking open ribs or pans, to prevent the ingress of water, wind, and vermin. | bird-proofing; filler block; foam seal |
| **Coating mass** | | The weight of the metallic protection given to steel by a zinc or aluminium/zinc coating, usually described in grams per square metre (g/m2), e.g., Z 450, AZ 150. Sheet or coil is measured and described as including both sides. Articles which are hot dipped after fabrication are measured and described as including one side only. | |
| **Code of practice** | COP | Prescriptive quantitative and qualitative criteria by which a product or system can comply with specified performance requirements. | |
| **Codemark** | | Codemark is a product certification scheme, supplied by an accredited certification body, showing that a product meets the requirements of the Building Code. Building Consent Authorities must accept a Codemark product-certificate as evidence of compliance with the NZBC. | |
| **Coil-coating** | | The continuous application of a metallic or organic coating to a metal coil. | |
| **Cold rolling** | | A metal thickness reduction manufacturing process, by applying pressure to metal coil at moderate temperatures. | |
| **Cold Soldering** | | Using a sealant or adhesive to bond two pieces of metal together. | Soldering |
| **Collar** | | A round over-flashing attached and sealed to a pipe to weatherproof a penetration. | |
| **ColorCote®** | | Pre-painted steel and aluminium for use as roofing, wall cladding, or roofing accessories, manufactured by Pacific Coilcoaters. | |
| **Colorsteel®** | | Pre-painted steel for use as roofing, wall cladding, or roofing accessories, manufactured by New Zealand Steel | |

| | | |
|---|---|---|
| **Composite roof** | A factory insulated panel with metal cladding on both sides used to cover a roof or a wall. | sandwich panel; composite panel; panel roof; cool room panel |
| **Concealed fastening** | A method of fixing a roof by means of hidden, or secret fixing clips or brackets. | secret fix; clip fix |
| **Condensation** | The process by which a vapour such as water vapour changes phase to a liquid. | Sweating |
| **Conduction** | The transmission of heat through a material by contact between the particles of matter. | |
| **Contractor** | A person or company who enters a verbal or written agreement with another party to perform an agreed scope of work. | roof fixer |
| **Convection** | The transport of heat within a gas or a fluid by the relative movement of those parts that differ in density. | |
| **Corrosion** | The process by which something erodes because of a chemical reaction. | rust |
| **Corrugate** | A profiled sheet formed into a series of sinusoidal or circular curves. | corrugated iron |
| **Counter-batten** | A spacer of timber or steel fixed to a purlin or batten, running transversely to the purlin. | |
| **Cover** | (a) The net width of sheeting less the lap.<br>(b) The net width of a flashing that covers sheeting. | effective cover |
| **Creep** | (a) The metal deformation, or a change in shape that increases continuously when under constant load or stress.<br>(b) The change in a sheets laying module when subsequent sheets are laid out of line or out of square. | |
| **Crest** | The top surface of a rib or corrugation | crown; rib |
| **Crevice corrosion** | The rapid pitting corrosion that occurs in crevices, pockets, or fissures when a patina or oxide film is prevented from forming or reforming by the concentration or depletion of dissolved salts or oxygen in stagnant water. | |
| **Cricket** | A metal roof flashing designed and constructed to divert water around a penetration and to avoid ponding. | raised curb |
| **Crimp curving** | A method of forming a curve on profiled sheeting by discrete indentations; causing a concave curve in the rib or a convex curve in pan | |
| **Crown** | The top of a curved roof or rib. | |
| **Cupola** | A small roofed structure on a ridge to provide ventilation, or designed for aesthetic purposes. | |
| **Curb** | A gutter or apron flashing around a penetration. | kerb |
| **Cyclonic winds** | Strong winds rapidly spiralling clockwise into a centre of low pressure in the Southern hemisphere. | hurricane; typhoon |
| **Deck** | The substrate of a structure that supports claddings that require to be fully supported. | |

| | | | |
|---|---|---|---|
| **Decking** | | A predominantly flat profile roof or wall cladding. | tray; secret fixed trough |
| **Deflection** | | The deviation from a straight line induced by a load or action. | |
| **Deformed shank nail** | | Nails with annular, spiral or otherwise deformed shanks. | enhanced shank nails |
| **De-indexing** | | The releasing of interlocking profiled sheets. | |
| **Depth** | | The vertical height of a rib or gutter. | |
| **Design wind load** | | The site design wind pressure in kilopascals (kPa) on a specific part of a structure, modified by pressure coefficients. | |
| **Design wind speed** | Vdes | The design wind load expressed as wind speed. | |
| **Dewpoint** | | The temperature at which water vapour condenses, which varies with the relative humidity and the pressure. | |
| **Ding** | | A permanent creasing of a rib or sheet, usually due to damage on a roof, resulting in structural depreciation. | |
| **Diverter** | | (a) A penetration flashing design used to prevent the accumulation of dirt and debris, which diverts the water runoff by folding the back curb at an angle to the penetration.<br>(b) An angle fastened to a flashing to channel water away from a penetration, obstruction or a wall. | |
| **Dog-ear** | | A three-dimensional box-like internal corner formed in metal without cutting. | pig's lug; stop end |
| **Dominant opening** | | An opening in the external surface of a closed building, greater than opposing openings, which directly influences the internal wind pressure. | |
| **Dormer** | | A roofed window structure projecting at right angles from a sloping roof surface. It can be configured as a shed dormer, gable dormer, or eyebrow dormer. | |
| **Downpipe** | | A pipe used to carry roof water from gutters and roof catchments to drains or storage tanks. | downspout |
| **Downturn** | | That part of the trough of a sheet turned down into a gutter. | turndown |
| **Drape curving** | | The use of metal cladding to cover a curved roof, using its own weight and not being pre-curved. | spring curving |
| **Dressing** | | The operation of flattening or beating metal into the required shape. | bossing |
| **Drip** | | (a) An outward projecting edge formed on a metal flashing to direct water away from the building or to avoid capillary action.<br>(b) A step or break in a roof or gutter, across the direction of fall. | birds beak; tip; kick; break |
| **Dropper** | | A spouting or gutter outlet. | pop |
| **Dry film thickness** | DFT | The thickness of a cured organic coating applied to a metal substrate. | film build |
| **Ductility** | | The ability of metal to withstand elongation without fracture. | |
| **Duopitch** | | A roof having two differing sloping pitches. | |
| **Durability** | | The ability of a material to withstand the corrosive action of the elements, and comply to the structural and functional requirements of the design performance criteria for a specified time. | |

| | | | |
|---|---|---|---|
| **Dutch gable** | | A type of roof frame that is partially hipped but which terminates as a gable. | |
| **Dynamic pressure** | | Fluctuating load normally caused by wind forces. | |
| **E2/AS1** | | An Acceptable Solution to the NZBC clause E2 External Moisture issued by the MBIE. | |
| **Eaves** | | The protruding edge of a roof slope. When enclosed it is known as a soffit. | |
| **Eaves gutter** | | An external roof gutter located under a roof overhang or the lower edge of a roof. | spouting |
| **Edge protection** | | A guardrail or restraint designed to prevent a person reaching over a roof edge or falling from a height. | |
| **Elastic limit** | | The limit to which a material can withstand stress under load without any noticeable or measurable permanent deformation. | |
| **Electrochemical series** | | The order in which metals react with one another in an electrolyte, with the electro-negative metal corroding in preference to the electropositive metal. | electromotive or galvanic series |
| **Electrolysis** | | The chemical change or decomposition produced in an electrolyte by an electric current. | |
| **Electrolyte** | | A solution such as water that contains ions, thereby becoming electrically conductive. | |
| **Electrolytic cell** | | A cell containing an electrolyte which produces an electrochemical reaction when an electric current pass through it. | |
| **Electrolytic corrosion** | | Galvanic corrosion commonly resulting from the contact of two dissimilar metals when an electrolyte, such as water, is present. | |
| **Elevation** | | The part of a drawing which shows the front, side or end view of a structure. | |
| **Emittance** | | The property of a surface to reradiate infra-red heat. Polished or shiny metal surfaces are poor emitters and dull dark surfaces are good emitters. | |
| **EPDM** | EPDM | A thermosetting synthetic rubber of ethylene, propylene, diene, monomer or terpolymer used as a resilient part of a sealing washer or as a roof membrane. | |
| **Erosion** | | The attrition of organic or metal coatings by natural weathering. | |
| **Escarpment** | | A steeply sloping face separating two relatively level plains, where the plains' average slope is less than 5°. | |
| **Eutectic point** | | The melting point of an alloy that is lower than the melting points of the elements or metals within it. | |
| **Expansion joint** | | A joint in a long length of roof cladding, gutter, spouting or flashing designed to allow for thermal expansion and contraction. | |
| **Eyebrow dormer** | | A roofed window structure with a curved roof projecting from a sloping roof surface. | |
| **Fall** | | The slope of roof or wall cladding or gutter usually expressed in degrees, or as a ratio of vertical height to horizontal distance (e.g., 1 in 20 = 3°) | |

| | | |
|---|---|---|
| **Fanning** | The spreading of roof or wall cladding at the gutter or ridge that results in the sheeting being out of square with the building. | sawtoothing; creep |
| **Fascia board** | A vertical board fixed to the bottom of the rafters, or trusses, to carry a spouting or gutter. | |
| **Fascia gutter** | (a) A square gutter formed to resemble a fascia.<br>(b) A concealed eaves gutter system that interlocks with a vertical or near vertical metal facing. | |
| **Fasteners** | Nails, screws, clips, and bolts, which are used to fix components of a roof assembly together. | fixings |
| **Fatigue** | The condition that induces weakness or cracking in a metal component by continued fluctuating stress, resulting in fracturing. | |
| **Filler blocks** | Shaped closed cell plastic pieces inserted into the rib ends or pans of profiled metal cladding, to prevent the ingress of wind, water and vermin. | seal; foam; foam sealer |
| **Fillet** | A supporting infill, installed at the point where vertical and horizontal surfaces meet, to support flashings and to avoid the build-up of dirt and debris in a sharp corner. | |
| **Film thickness** | The thickness of a paint or other coating usually expressed in microns. (µm). Wet film thickness is the thickness of a coating as applied. Dry film thickness is the thickness after curing. | film build |
| **Fixing** | The method of attachment of cladding to the frame achieved using fasteners. | |
| **Flame retardant** | A material to which a substance has been added to reduce or retard its tendency to burn. | |
| **Flashing** | (a) A metal covering, built in to prevent moisture movement or the ingress of water to the inner parts of a building.<br>(b) A component used to weatherproof, vermin-proof or seal the roof and wall cladding corner, ridge, perimeter, penetration, expansion joint, valley, gutter and other places where the roof covering is interrupted or terminated. | Apron; Barge; Back; Capping; Corner; Curb; Overcloak; Raking; Ridge; Secret; Sill; Skirt; Soaker; Soft-edge; Stepped. |
| **Flat roof** | A roof having a slope between 0° and 5°. | |
| **Flux** | A chemical liquid or substance used to clean and remove oxide or other film from a metal prior to soft or hard soldering or brazing. | |
| **Folding** | A manufacturing method used to permanently deform metal over a small radius to the desired angle. | brake pressing |
| **Free roof** | A roof without enclosing walls; e.g., a carport. | |
| **Fretting** | Damage to a metal surface or coating between adjacent surfaces caused by movement and friction; e.g., during transportation. Normally, fretting only causes aesthetic damage. | |
| **Fully supported cladding** | Metal cladding that requires a solid substrate to provide strength for wind or point loads. | tray roofing; standing seam sarked roof |

| | | | |
|---|---|---|---|
| **Gable** | | The triangular end wall surface of a building above the plate line where the rafters meet the apex at the ridge. | |
| **Gable roof** | | A ridged roof having two slopes only, with a gable at each end. | |
| **Galvanised steel** | | Steel protected against corrosion by a hot-dipped zinc-coating described as Z. | |
| **Galvanising** | | The process by which steel is coated by dipping it into a bath of molten zinc, measured by weight in g/m2 or thickness in microns (µm) | |
| **Gambrel** | | A roof that has two pitches on each side, similar to a Mansard roof. | |
| **Gauge** | | The thickness of metal described in millimetres or inches, previously known as a non-measured number. | |
| **Geothermal hotspot** | | A location that exhibits any geothermal activity such as steam, water or fumes emitting from the ground, hot water or mud pool. | |
| **Girt** | | A structural horizontal wall member in a wall between columns used to fix or support wall sheeting. | |
| **Good trade practice** | | Trade habits used by members of an industry, having a history of successful usage and having a higher standard than Acceptable Trade Practice. | |
| **Grade** | | The mechanical strength of a metal complying with relevant standards. | |
| **Groover** | | A hand tool used for seaming sheet metal. Also known as a Seamer. | |
| **GRP** | GRP | Glass fibre reinforced polyester translucent or opaque sheeting, used for roof lighting and manufactured to match profiled sheeting. | |
| **Gutter** | | A channel formed to collect and carry water away from a roof, variously described as internal, external, box, eaves, valley, and internal or external secret. | |
| **Half-round** | | A spouting or eaves gutter having a half circle cross-section. | |
| **Hard Soldering** | | Using an alloy of silver and copper to bond two pieces of compatible metals together at approximately 735°, also known as silver soldering or brazing. | soldering; silver soldering; brazing |
| **Head flashing** | | A flashing at the top of an opening or penetration. | |
| **Hem** | | A flat but open metal edge folded 180°. | safety edge |
| **Hertz** | Hz | A metric or SI unit of frequency equal to one cycle per second used when cyclic testing metal roof and wall cladding. | |
| **Hex head** | | A self-drilling or self-tapping screw with a hexagon (six-sided) head. | |
| **High strength** | | Unannealed metals that have a high yield strength relative to their ultimate strength. | |
| **Hip** | | The external angle formed on a roof where two inclined faces meet. | |
| **Hipped roof** | | A roof with a level eave and with its ends inclined as well as its sides. | |
| **Holiday** | | A small pinhole or area where a liquid applied paint coating or laminate film material is missing. | skip |
| **Hook** | | An open hem used on a hidden under-flashing to prevent water ingress. | |

| | | | |
|---|---|---|---|
| **Humidity** | | The amount of water vapour suspended in the air. The state or quality of being damp. | |
| **Impermeable** | | A barrier preventing the passage of a liquid or vapour. | vapour barrier |
| **Inert catchment corrosion** | | The phenomenon where rainwater or condensation, flowing over inert materials such as glass, plastic, or coated metals cause accelerated corrosion of downstream galvanised metal. | |
| **Interstitial condensation** | | Condensation that occurs within an enclosed cavity of a wall or roof. | |
| **Jenny** | | A hand tool used to turn an edge on a curved flashing. | |
| **Joggle** | | A double offset fold used to accommodate metal thickness. | crank |
| **Kilonewton (kN)** | | A unit of force applied to a specific area equalling a thousand Newtons. As the unit value of a Newton is inconveniently small, such forces are commonly expressed in kilonewton. | Newton |
| **Kilopascal** | kPa | Kilopascal kPa A unit of pressure over an area equalling a thousand Pascals. As the unit value of a Pascal is inconveniently small, pressures are commonly expressed in kilopascals. 1 kPa = 1 kN/m2 | Pascal |
| **Lap** | | (a) That part of a flashing or sheet that overlaps or covers any portion of the same shaped component, and variously described as overlap and underlap.<br>(b) The total part of a flashing that laps another dissimilar component, including the cover. | |
| **Lap tape** | | An adhesive strip made from UV resistant materials used as a joint sealant or part of a roof system. | |
| **Lean-to** | | A mono-pitch or single slope roof attached to another structure, but at a lesser pitch. | shed roof |
| **Leeward** | | The opposite direction to that from which the wind is blowing (windward). The side sheltered from the wind. | |
| **Licensed Building Practioner** | LBP | A person issued with a renewable licence having satisfied the Building Practitioners Board that he or she meets the minimum standard of competence for each class of licence. | |
| **Lightweight roof** | | A roof cladding which has a mass not exceeding 20 kg/m2. | |
| **Limit state** | | A design method having two parts:<br>(a) Serviceability Limit State: The state when a building, or any part of it, becomes unfit for its intended use due to deformation or deflection.<br>(b) Ultimate Limit State: The state associated with collapse or failure, or when a building or any part of it becomes unstable or unsafe. | |
| **Load** | | The value of a force resulting from an action. | |
| **Load spreading washer** | | A metal washer formed to match the ribs of profiled sheeting to provide support to the sheeting at the fastening under high wind loads. | profiled washer; cyclone washer; top washer |

| | | | |
|---|---|---|---|
| **Loads** | | Loads or actions that the structure or roof or wall cladding must be designed to support, as required by building standards or codes.<br>(a) A dead load is the weight of the permanent structure including the roof.<br>(b) A live load is a superimposed load such as foot traffic on the roof.<br>(c) A wind load is that load imposed on the structure by the action of the wind. | |
| **Local pressure coefficient** | kl | A factor applied to the design wind load due to the dynamic increase of the wind around the periphery of walls or roofs. | kl; local pressure factor |
| **Long-run** | | Long length roll-formed roof and wall cladding fixed in one length without transverse laps. | |
| **Low pitched roof** | | A roof having a slope between 5° and 10°. | |
| **Macro-climate** | | The climate of a large geographical area. | |
| **Maintenance** | | A planned set of activities regularly performed during the design working life of a structure to enable it to fulfil durability and functional requirements. Maintenance can be divided into two types:<br>(a) Normal: That which can be undertaken without special equipment, e.g., washing.<br>(b) Special: That which requires specialised skills or equipment. | |
| **Mansard** | | A roof with two pitches, having a break in the slope, the lower part being steeper than the upper. | gambrel |
| **Membrane** | | A non-metallic material used in conjunction with metal roof and wall cladding as gutters and penetrations, or as a fully supported roof cladding. | |
| **Metal cladding** | | Formed metal commonly used in the roofing industry in New Zealand; including metallic coated steel, aluminium, stainless steel, copper, and zinc. | |
| **Micro-climate** | | The climate of a small specified area; e.g., under eaves, near the seashore or in an enclosed cavity. | |
| **Micro-cracking** | | The small cracking that occurs on external or tension bends of galvanised and aluminium/zinc coating on steel during forming, the extent of which is interdependent on coating thickness and bend radius. | |
| **Micrometre** | μm | A millionth of a metre, used as a measure of the thickness of metallic and organic films. | micron |
| **Ministry of Business, Innovation and Employment** | MBIE | The Government department regulating economic development, science and innovation, labour, and building and housing. MBIE also authorises BCA's and publishes the NZBC. | |

| | | | |
|---|---|---|---|
| **Monel® alloys** | | Any of a group of nickel-based alloys, developed in 1905, containing between 29 and 33 percent copper, with small amounts of iron, manganese, carbon, and silicon. Monel alloys are stronger than pure nickel and resistant to corrosion by many agents, including rapidly flowing seawater.<br>They can be fabricated readily by hot- and cold-working, machining, and welding. It is often used as rivets, fasteners or clips. Monel is a registered trademark of the International Nickel Company. | |
| **Monopitch** | | A roof having one constant slope with no ridge. | mono-slope; lean-to |
| **Nesting profiles** | | Cladding profiles that closely stack together. | |
| **Netting** | | An open weave lightweight material used under roof cladding as a support for underlay | mesh; wire netting |
| **Newton** | N | The force needed to accelerate one kilogram of mass at the rate of one metre per second squared in direction of the applied force. | |
| **Neutral-cure silicone** | | A sealant with a neutral pH, that does not cause corrosion. | |
| **Night sky radiation** | | A phenomenon where a roof can become up to 5°C colder than the ambient temperature by radiating heat to a clear night sky. | |
| **Noble metal** | | A metal that is less active or likely to corrode when in contact with others. | |
| **Non-ferrous** | | Metals made from elements other than iron. | |
| **Notching tool** | | A hand tool used to remove a section of flashing that fits over a rib. | |
| **Obtuse angle** | | An angle between 90° and 180°. | |
| **Ogee** | OG | A kind of sigmoid curve, somewhat shaped like an "S", consisting of two arcs that curve in opposite senses, so that the ends are parallel; it is often used in moulding. | |
| **Oil canning** | | Distortion in the form of waviness or centre fullness in a profiled sheet. | canning; panning |
| **Organic coating** | | The paint film of a pre-painted metal product or a laminate film of a laminated metal product. | |
| **Overflow** | | An additional or alternative outlet for a gutter, spouting, rainwater head, or sump to harmlessly dispose of abnormal rainwater runoff or caused by blockages of the primary outlet. | |
| **Oversized Hole** | | A larger than normal hole to allow for expansion or other reasons. When required, it is to be made using a 9 mm drill unless otherwise specified. | |
| **Oxide** | | A chemical compound of oxygen and metal that will form as a film on the surface of metals on exposure to the atmosphere. | |
| **Pan** | | The flat portion between the ribs of a profiled metal sheet. | |
| **Pan fixing** | | The fixing of cladding through the flat pan, used when fastening wall cladding, stressed skin, and composite roof cladding. | |
| **Pan Roof** | | A standing seam roof may be called a pan roof. | standing seam roof |

| | | | |
|---|---|---|---|
| **Parapet** | | The part of a perimeter wall immediately adjacent to the roof, and which extends above it. A parapet higher than one metre is termed a parapet wall. | (incorrectly) enclosed balustrade wall |
| **Pascal** | Pa | A unit of measure equalling one Newton per square metre | |
| **Patina** | | A thin, visible, stable film of oxide, carbonate, or other chemical reaction coatings which forms on the surface of metal on exposure to the atmosphere. | |
| **Peening** | | The permanent deformation or working of metals using a ball peen hammer. | |
| **Penetration** | | A projection through a roof or wall; e.g., vent pipe, air-conditioning unit window, or doorway. | protrusion |
| **Penultimate** | | The next to last or the one before the last one. | |
| **Perforation** | | Deterioration of metal due to corrosion or erosion that results in a hole. | |
| **Performance** | | Quantitative and qualitative criteria which a product or system has to achieve to comply with the NZBC or other relevant Standards. | |
| **Permanent ponding** | | When free water is evident for more than three days in spouting, gutters or on roof or wall cladding. | |
| **Permeability** | | The measure of the rate of a porous material to permit a gas or liquid to move through it in a unit time, area, and pressure. It depends on the density of both materials and the temperature. | |
| **Permeable membrane** | | An underlay or other sheet material that permits the passage of water vapour. | breather type; permeable underlay. |
| **Personal protective equipment** | PPE | Safety equipment that is personal to the employee or the person to whom it is issued; e.g., safety boots, gloves, ear plugs, etc. | |
| **pH** | pH | A unit-less logarithmic measure of acidity or alkalinity graduated from 0-14; pH 7 is neutral, below which is more acidic, above which is more alkaline. | |
| **Pitch (1)** | | The slope or rake of a roof expressed in degrees from the horizontal or as a ratio of vertical height to horizontal distance, e.g., 1 in 20 = 3°. Also known as fall, and the tangent of the pitch angle.<br>A roof is described by its pitch:<br>(a) Less than 5° is flat.<br>(b) From 5° to 10° is low pitched.<br>(c) Roofs from 10° to 30° is pitched.<br>(d) A slope of 30° to 60° is steep-pitched.<br>(e) Over 60° is known as Elizabethan. | |
| **Pitch (2)** | | The distance between the centres of two ribs. | |
| **Pitch (3)** | | The distance between threads of a screw, usually expressed as Threads Per Inch (tpi) | |
| **Pitched roof** | | A roof with a slope between 10° and 30° with a ridge at the highest point. | |
| **Pittsburgh lock** | | A type of seam used to interlock two pieces of metal together. | lock- formed seam. |

| | | |
|---|---|---|
| **Plans and Specifications** | Drawings, written requirements and other related documents according to which a building is to be constructed or altered. | |
| **Point load** | A load, normally downwards, applied either permanently or temporarily to a defined specific section of cladding | |
| **Polycarbonate** | A clear thermoplastic polymeric resin, formed into matching roof and wall cladding profiles, or curved flat sheeting used to provide natural roof lighting. | |
| **Ponding** | Any free undrained water retained for more than three days after cessation of flow on roof cladding, flashings, or a gutter due to insufficient fall. It can also be caused by permanent deflection or deformation of a roof. | |
| **POP® Rivets** | Pop rivets are typically used with sheet metal to securely connect two more components. It is a registered trademark owned by Stanley Engineered Fastening. | |
| **Pre-curved** | A metal cladding profile that is curved off-site, by progressive forming through a pyramid roll or crimp-curve machine. | |
| **Pre-painted** | Base metal strip or sheet, in line painted to give protection or aesthetic appeal prior to subsequent forming, shaping or fabrication. | prefinished; pre-coated. |
| **Pressure coefficient** | A ratio of the pressure on the surface area of a structure to the free dynamic pressure of the wind. It depends on the size, shape, height and the location of the building and the number and position of its openings. | Pressure Factor (internal, external, local, positive and or negative) |
| **Pressure equalisation** | A design of penetration flashing that relies on the complete inner seal of the penetration between it and the frame. A partial pressure equalisation design is termed pressure moderated. | |
| **Producer statement** | A detailed statement made by a manufacturer, designer or installer, about the durability, installation and performance of a product or building system, and which claims all manufacturing, design and installation will be or has been carried out in accordance with specific requirements. | |
| **Product Certificate** | A renewable certificate issued by an accredited certifier for a period of three years certifying the product when used within its scope of use and installed under specified conditions, complies with Building Code requirements. | BRANZ appraizal; third party certificate; codemark |
| **Profile** | The cross-section of metal cladding, generically known as corrugated (sinusoidal), trapezoidal (ribbed), trough, tray, or standing seam. | corrugated (sinusoidal); ribbed (trapezoidal); troughed; boxed or tray |
| **Profiled sheeting** | Metal sheeting produced with corrugations or ribs to increase its strength. | long run |

| | | | |
|---|---|---|---|
| **Pucker** | | The unacceptable distortion of metal flashings due to an incorrect fit. | |
| **Pull-out** | | The failure of a fastener when it is pulled out of the structure; e.g., by the uplift force of the wind. | |
| **Pullover** | | The failure of the sheeting when it pulls over the head of the fastener or washer; e.g., by the uplift force of the wind. | |
| **Pull-up stop-end** | | An end closure of the pan of profiled cladding formed without cutting the ribs and forming pig lugs. | |
| **Purlin** | | A horizontal secondary structural member supporting roof cladding. | |
| **PVC** | PVC | A clear or opaque polyvinyl chloride thermoplastic resin, formed into matching cladding profiles to provide natural roof and wall lighting, and rainwater goods. | |
| **Quarter-round** | | A spouting or eaves gutter with a straight back, and a cross-section of a quarter segment of a circle. | quad; D |
| **Radiation:** | | The transmission and emission of infra-red energy in the form of electromagnetic waves. | |
| **Rafter** | | A sloped primary structural member that extends from the ridge to eave designed to support secondary members and the roof cladding. | |
| **Rain collar** | | A conical flashing fitted over a pipe to weather the penetration. | rain hat; chinese hat; boot flashing |
| **Rainwater goods** | | Any building product used for rainwater disposal including downpipes, rainwater heads, sumps, spreaders, eaves gutters, spouting, and valleys. | |
| **Rainwater head** | | An external box designed to collect rainwater from a gutter. | rainhead |
| **Red rust** | | The formation of a reddish-brown oxide on the surface of steel or iron. | corrosion; rust; cancer |
| **Relative humidity** | | The ratio of the mass of water vapour in a volume of air, compared to the value that saturated air could contain at the same temperature and pressure. | |
| **Return period** | | The average number of years within which a given wind gust or rainfall is expected to be equalled or exceeded. | ARI; average return interval |
| **Return stopend** | | The end of a spouting or gutter that has the profile face carried around the stopped end. | |
| **Rib** | | A longitudinal up-stand produced by roll-forming, folding or crimping to strengthen or stiffen metal cladding. | crest upstand |
| **Rib cap** | | A small metal flashing to weather a rib at a change of pitch. | prickles; sharks teeth; end cap; profile end |
| **Ridge** | | (a) A long crest or chain of hills with sloping faces.<br>(b) The top of a ridging or profile.<br>(c) The level intersection point of two opposing planes of roofing. | crest. |
| **Ridge cap** | | (a) A small capping to weather the join in the ridging used at a change of pitch or direction on metal cladding.<br>(b) A formed metal tile used at a ridge. | (a) Hip-cap. |

| | | | |
|---|---|---|---|
| **Ridge vent:** | | A prefabricated ventilator used in lieu of ridging that allows the escape of warm or moist air from a building. | vent-ridge. |
| **Ridging** | | A metal flashing, roll topped, square or otherwise strengthened, which can be plain or soft-edged, used to cover the joint of the roof cladding at the ridge, apex, or hip-end. | |
| **Roll** | | A piece of shaped timber used in fixing fully supported roof or wall cladding. | |
| **Roll curved** | | Symmetrical cladding profile that is curved off-site by progressive forming through a pyramid roll machine. | |
| **Roll formed** | | A manufacturing process by which metal is progressively formed from flat sheet or coil into a profiled sheet by a series of shaped rolls. | long run |
| **Roof** | | The surface of a structure or building designed to shelter the space below it against the elements and to discharge rainwater outside the building. | roofing |
| **Roof light** | | Translucent profiled GRP, Polycarbonate or PVC cladding, or glass inserted into a roof surface provide natural lighting. | skylight; roof window; clear sheet |
| **Roofer** | | A person who covers a roof. | |
| **Roofing** | | The act of constructing or covering a roof. | roof |
| **R-Value** | R | R-values rate how much heat loss the material resists from passing through it; U-values rate how much heat the component allows to pass through it. R-values rate one single material while U-values measure entire components. For example, R-values measure how much heat loss passes through fibreglass insulation while U-values rate how much heat can pass through a window component (glass, air, vinyl sash).<br>Typical insulation might have an R-value of 19 while a window might have a U-value of 0.35.<br>R = 1/U. So a U-value of 0.35 would equal an R-value of 2.86. As you can see from this example, windows have a MUCH lower R-value than a properly insulated wall. | U-Value |
| **Saddle** | | (a) A shaped piece of metal used to weather the junction between a horizontal and vertical surface.<br>(b) A small metal support used to reinforce a damaged rib on the rib of roof or wall cladding. | |
| **Safety edge** | | A small edge turned at 180° on the cut edge of a metal component in order to avoid personal or property damage. | hem |
| **Safety harness** | | An assembly of interconnected shoulder and leg straps, used where a person could fall from a height. | fall arrest harness |
| **Safety mesh** | | A safety wire netting used to prevent workers from falling through a roof. It can also function as an underlay support | underlay support |
| **Sarking** | | Timber boards or plywood fastened to rafters, trusses or purlins as a roof support for metal cladding. | |
| **Sawtooth roof** | | A trussed roof construction that is in the shape of the teeth of a saw, requiring gutters at the bottom of the near vertical face. | |

| | | |
|---|---|---|
| **Scotch Ridge** | The termination of a lower ridge where it meets the intersection of two valleys. | |
| **Screw gun** | An electric or battery driven driver, with a torque limiting or depth limiting device, used for driving self-drilling, self-tapping screws or other types of screw. | |
| **Scupper** | A horizontal opening in the side-wall of a gutter, spouting, parapet wall, or enclosed balustrade to allow drainage. | |
| **Sealant** | A single- or multi-component polymeric material used to waterproof metal joints, in conjunction with mechanical fasteners. | |
| **Sealing washer** | A rubber EPDM or neoprene washer, sometimes metal-backed, assembled on a fastener and used to prevent water from entering through a fastener hole. | metal-backed washer |
| **Seaming** | A method of joining two separate sections of metal by mating their two interlocking parallel edges, variously described as lock-formed, grooved, lock-seam, Pittsburgh lock, single and double welt, snap-lock, or knocked-up. | Lock-formed; grooved; lock-seam; Pittsburgh lock; single and double welt; snap-lock; knocked-up |
| **Secret flashing** | A flashing hidden from view or embedded within a wall or wall cavity. | |
| **Secret gutter** | A gutter partially or completely hidden from view, used when roof cladding is cut on a diminishing angle at the barge end. At roof pitches over 12° it is termed a secret valley gutter. | Secret valley gutter |
| **Secret-fix** | A roof or wall cladding system that has no visible or exposed fixings. | clip fix; hidden fix |
| **Section properties** | Values assigned to specific profiles determined by their geometrical shape. | |
| **Secure footing** | The ability of a person to walk safely, without assistance, on a roof with a pitch smaller than 35°, being dependent on the type of shoes worn and the type of surface. | |
| **Self-drilling screw** | A fastener that drills and taps its own hole. | TEK® screws; drill bit screws |
| **Self-tapping screw** | A fastener that self-threads when turned into a previously drilled hole; not the same as a self-drilling screw. | |
| **Shake** | (a) A shake is a basic wooden shingle made from split logs.<br>(b) An interlocking coated metal tile, impressed to resemble timber shakes. | |
| **Shank** | The original diameter of a nail, screw or bolt before heading, threading, or deformation. | |
| **Shear** | The scissor action of any tool used to cut metal. | |
| **Shear force** | A force that causes deformation by producing an opposite but parallel sliding motion. | |
| **Shed roof** | A lean-to roof having no hips or valleys and containing only one sloping plane. | |

| | | |
|---|---|---|
| **Sheeting** | Any metal, GRP, or plastic roof or wall cladding. | |
| **Shingle** | (a) Thin, tapered pieces of wood primarily used to cover roofs and walls of buildings. Today shingles are mostly made by being cut, which distinguishes them from shakes which are made by being split out timber.<br>(b) An interlocking coated metal tile, impressed to resemble timber, composition or modified bitumen shingles. | |
| **Shoe** | A downpipe angle at the discharge point. | elbow |
| **Side lap fixing** | The system by which one sheet is fixed to an adjacent sheet through the side of their lapping ribs. | |
| **Sill flashing** | A flashing at the bottom of a window or door opening or penetration. | tray flashing |
| **Sinusoidal** | A profile shaped with a series of arcs of a circle resembling part of a sine curve. When these are symmetrical about a centre line they are known as corrugated. | |
| **Skew** | A roof or fastener at an angle or out of square. | |
| **Skew nailing** | A method of driving nails in at an angle to the surfaces being nailed. | |
| **Skillion roof** | A pitched roof with the ceiling fastened and installed at a parallel pitch to the roof. | |
| **Skirt** | A separate over-flashing used to weather penetration curb flashings. | |
| **Skylight** | A unit of plastic sheet, glass or an Acrylic dome providing natural light through a roof. | roof window |
| **Slip joint** | An over-flashing fixed to one side only, to allow for expansion. | |
| **Snips** | A metal tool used to cut metal, having variously shaped cutting blades, variously described as straight, curved, gilbow, circular, aviation, left-hand, right-hand, or tinmans. | tin snips; shears |
| **Snow-boards** | A timber or metal platform built over a gutter to prevent blockage by snow or hail. | hail-boards; gutter-boards |
| **Soaker** | An under flashing, partially hidden, that prevents water ingress by means of hooked edges. | |
| **Soffit** | The enclosed underside of any exterior eave overhang. | eave |
| **Soft Soldering** | Using a lead/tin alloy that is melted to bond two pieces of compatible metals together at approximately 200°C; | soldering |
| **Soft-edge** | A compatible soft metal edging — usually lead, aluminium, or composite material — seamed onto flashings to provide a closure to profiled cladding and to exclude the weather and vermin. | |
| **Soldering** | A method of joining of metals together by forcing melted metal into a joint. | |
| **Sole** | The bottom surface of a gutter. | |
| **Span** | The centre distance between two fixing points. The clear distance between two supports is known as the clear span. | clear span |
| **Spanbreaker** | An intermediate supporting member placed under or over roof cladding at a rooflight or a penetration to minimise deflection or traffic damage on large spans. | mid-span support |
| **Specular gloss** | The measure of the reflective surface of an organic film at a defined angle. | |

| | | |
|---|---|---|
| **Spiral shank nail** | A nail having its shank formed with helical grooves so that it rotates when driven. | twisted shank |
| **Spouting** | An external gutter. | 1/4 round; quad; D; 1/2 round; OG; square |
| **Spreader** | A downpipe tee or elbow fixed at 90° to the roof slope and used to spread the discharge of stormwater over a greater area of the roof. | |
| **Spring curving** | An on-site method of installing straight lengths of profiled cladding to a convex or concave substrate. | drape curving |
| **Springback** | The elastic recovery of metal after deformation, which is more pronounced when forming high-strength metals. | |
| **Stainless steel** | A steel alloy containing a mixture of chromium, nickel and other trace metals to increase its durability. | |
| **Standing seam** | A fully supported metal roofing system that consists of an overlapping or interlocking seam that occurs at an upturned rib and is made by turning up the edges of two adjacent metal panels, then folding and interlocking them, once for a single seam and twice for a double seam. | pan roofing; tray roofing |
| **Static line** | A rope, wire or rail secured between two points, to support any fall protection device. | |
| **Steep pitch** | A roof having a pitch between 30° and 60°. | |
| **Step flashing** | A flashing that weathers a step in the roof when the rafter length is greater than the length of sheeting that is available or advisable. | waterfall joint |
| **Stepped flashing** | A short sloping apron over-flashing set into a wall chase in brick, weatherboard, or block construction. | |
| **Stop end** | (a) That part of a trough of a sheet turned up at the high end of a roof or wall or the lower end of a penetration. Can be "pulled up" or "dog-eared".<br>(b) An end closure for a gutter, spouting or flashing. | |
| **Stressed skin** | A term applied to roof or wall cladding that serves as a structural bracing diaphragm for a building. | |
| **Strip** | Flat metal, over 0.15 mm and under 3 mm thick, of any length and width — usually supplied in a coil. | |
| **Strippable film** | A plastic film applied to the surface of a metal sheet or strip to give temporary protection to the finish. It must be removed before prolonged exposure to sunlight. | |
| **Subcontractor** | A person or company who enters into a verbal or written agreement to perform specified work with the main or another contractor. | |
| **Substrate** | (a) The metallic surface to which a metal, organic or laminated film finish is applied.<br>(b) The surface upon which the roof cladding is applied or fixed. | |
| **Sump** | An internal rainwater head used to connect a gutter to downpipes. | |
| **Swage** | A small raised flat rib in a sheeting profile used to minimise distortion caused by centre fullness, or residual or other stress in the sheeting. | stiffener |

| | | | |
|---|---|---|---|
| **Swarf** | | Fine metallic filings or chips produced as debris from drilling, cutting, or grinding metal on a roof. | |
| **Sweat** | | (a) Visible water droplets as condensation on a smooth surface such as metal sheeting.<br>(b) A technique of soldering or brazing by the application of sufficient heat to fill the lap gap by capillary action with soft or hard solder. | |
| **Symmetrical profile** | | A profile that has the same configuration on opposite sides of a horizontal centre axis line. | |
| **Synthetic building paper** | | A synthetic roofing or wall cladding underlay. | |
| **Tab** | | A small folded angle or projecting flap formed on a flashing to provide fixing. | |
| **Tag-line** | | A rope that is used to guide a free-swinging load from a crane. | |
| **T-bend** | | The internal bend diameter expressed in terms of thickness used to define the external radius; i.e., 6 T bend = 4 T radius. | |
| **Tek® Screw** | | A proprietary name owned by Buildex for their self-drilling roofing screws for fastening into steel. Often misapplied to other manufacturer's steel fastening roofing screws and roofing screws generally. The name should not be used generically as that is misleading. | self-drilling screws |
| **Temper** | | A hardness condition of metals, determined by a manufacturing process or subsequent annealing. | |
| **Tensile strength** | UTS | The tensile limit when metal breaks under load, measured by the load divided by the original cross-section and expressed in MPa. (megapascals). | ultimate tensile strength |
| **Terrain** | | The surface roughness of the ground described by its openness or by obstructions such as trees and buildings that influence wind speed. | |
| **The New Zealand Building Code** | NZBC | The legal performance requirements as prescribed in the Building Act for building controls within NZ. | |
| **Thermal conductivity** | k | The rate at which heat passes through a material expressed as the amount of heat that flows per unit time, area and distance. | |
| **Tile** | | An interlocking metal pressing, shaped to resemble a clay tile. | |
| **Tinman's Rivet** | | A small headed solid fastener suitable for peening requiring access to both sides. | |
| **Topography** | | The hills, valleys and plains that strongly influence and accelerate wind flow patterns and the wind design load on a structure. | |
| **Tornado** | | A violently rotating column of air attached to the base of a convective cloud descending to the ground and often observed as a funnel. | |
| **Total coated thickness** | TCT | The measure of the total of the base metal thickness, plus any additional metal or organic coating. | |
| **Trade practice** | | Trade habits used by members of an industry, known variously as acceptable, good and bad. | |
| **Trade training** | | Tuition given to a trainee or workman by a qualified tradesman. | |

| | | | |
|---|---|---|---|
| **Tradesman** | | A workman or woman, having spent a prescribed period of time working at a trade; and who has been qualified by the successful completion of written and practical trade examinations. | |
| **Transverse** | | A flashing or fastenings running horizontally across the sheeting. | |
| **Trapezoidal** | | Profiled roof or wall cladding with longitudinal ribs angled similarly to a trapezoid. | rib profile |
| **Tray** | | The pan, trough or flat draining area of a deck-type of roof. | |
| **Tray roof cladding** | | A profile having a large flat area compared with the rib or seam. | deck roofing; trough roofing; fully supported roofing |
| **Turn-up tool** | | A hand tool used to form stop-ends or to turn down the ends of metal cladding. | stop ender |
| **Undercutting** | | The corrosion of a metal substrate under a paint film, caused by a score mark, edge or hole. | edge creep |
| **Underlay** | | A flexible membrane laid under roof or wall cladding to control condensation or provide reflectivity. | building paper |
| **Uniformly Distributed Load** | UDL | Used as a measure of the wind load on metal cladding, usually expressed in kPa (kilopascals). | |
| **Unwashed** | | Areas of roof or wall cladding protected from washing by natural rainfall at an angle of 45° by a projecting roof or overhang. | |
| **Upstand** | | The vertical face of a flashing or stop end. | |
| **U-Value** | U | R-values rate how much heat loss the material resists from passing through it; U-values rate how much heat the component allows to pass through it. R-values rate one single material while U-values measure entire components. For example, R-values measure how much heat loss passes through fibreglass insulation while U-values rate how much heat can pass through a window component (glass, air, vinyl sash). Typical insulation might have an R-value of 19 while a window might have a U-value of 0.35.<br><br>R = 1/U. So a U value of 0.35 would equal an R value of 2.86. As you can see from this example, windows have a MUCH lower R-value than a properly insulated wall. | R-Value |
| **Valley** | | A gutter at the internal intersection of two sloping panes of roof cladding. | |
| **Vapour barrier** | | A sealed impermeable membrane designed to eliminate the passage of water or water vapour. | vapour check |
| **Vapour control layer** | VCL | An impermeable membrane designed to minimise the passage of water or water vapour. | vapour check; vapour retarder |
| **Vented** | | A cavity that provides some degree of water vapour diffusion and air movement. | |
| **Ventilated** | | A cavity that has been designed to provide a significant flow of air or water vapour to the outside air, such as a ventilated ridge. The NZBC allows for drained, but not vented wall cavities. | |

| | | |
|---|---|---|
| **Walkway** | A permanent or temporary structure placed over metal roof cladding to enable access without causing damage or imposing a point load on the cladding. | cat-walk |
| **WANZ-WIS** | The Window Association of New Zealand's Window Installation System. | |
| **Watershed** | A penetration over-flashing type that extends to the ridge. | back flashing; dry pan flashing |
| **Weather:** | (a) The state of the atmosphere at a given time and place, specified by variables including, wind velocity, humidity, temperature and pressure.<br>(b) To cause a roof or flashing to shed water. | |
| **Weathering** | The visible change in a surface, such as the oxidation of metals, or chalking of pre-coated materials, due to atmospheric exposure. | Weathered |
| **Weatherproof** | (a) The ability to withstand exposure to weather without damage.<br>(b) To protect a building from the elements. | Weathertight |
| **Weathertightness** | The degree of protection offered from the elements. | |
| **Web** | The vertical or near vertical part of a rib. | |
| **Welt** | (a) An interlocking metal seam used when site fabricating roof sheeting.<br>(b) Folds on flashings or roof cladding joining two adjacent metal sheets together at their edges without fasteners. | single welt; double welt; cross welt |
| **Wet storage stain** | Corrosion effects due to condensation or rain penetration of nesting profiles. Also known as White Rust for galvanised, Black Rust for Aluminium Zinc coating, and Black Stain for Aluminium | white rust; black rust |
| **White rust** | The visible white corrosion product found on galvanised coatings in protected, unwashed, cut edges or micro-cracked areas. | bloom |
| **Wicking** | The movement of water through a porous material by capillary action. | |
| **Work hardening** | The reduction of metal ductility caused by cold working or movement in service. | |
| **Workman** | A man or woman employed in a trade, who is or has learned trade skills from their employer, supervisor or a technical institute. | |
| **Yield point** | The first stress point at which some metals will plastically and permanently deform. | |
| **Yield stress** | The recorded stress at the point of yielding. | |
| **Zinc aluminium coating:** | Steel protected against corrosion by a zinc dominated zinc/aluminium alloy. | ZA; Galfan or Galvalloy |

# 2.2 Domestic Cladding Terminology

## 2.2A Domestic Detail

## 2.2B Domestic Nomenclature

| | | | |
|---|---|---|---|
| 1 | Ridging | 16 | Recessed Window |
| 2 | Penetration | 17 | Rainwater Head |
| 3 | Ridge Cap | 18 | Roof Light |
| 4 | Ventilator | 19 | Concealed Gutter |
| 5 | Pressed Tiles | 20 | Butt Window Flashing |
| 6 | Underlay | 21 | Internal Corner |
| 7 | Tubular Roof Light | 22 | Horizontal Cladding |
| 8 | Valley | 23 | Flush Window Head |
| 9 | Cricket | 24 | Downpipe |
| 10 | Apex Ventilation | 25 | Secret-fix Roof Cladding |
| 11 | Barge | 26 | Apron |
| 12 | Apron | 27 | Collar Flashing |
| 13 | Roll Curving | 28 | Dormer |
| 14 | Curved Flashing | 29 | Safety Mesh |
| 15 | Fascia Gutter | 30 | Fixing Patterns |

# 2.3 Industrial Cladding Terminology

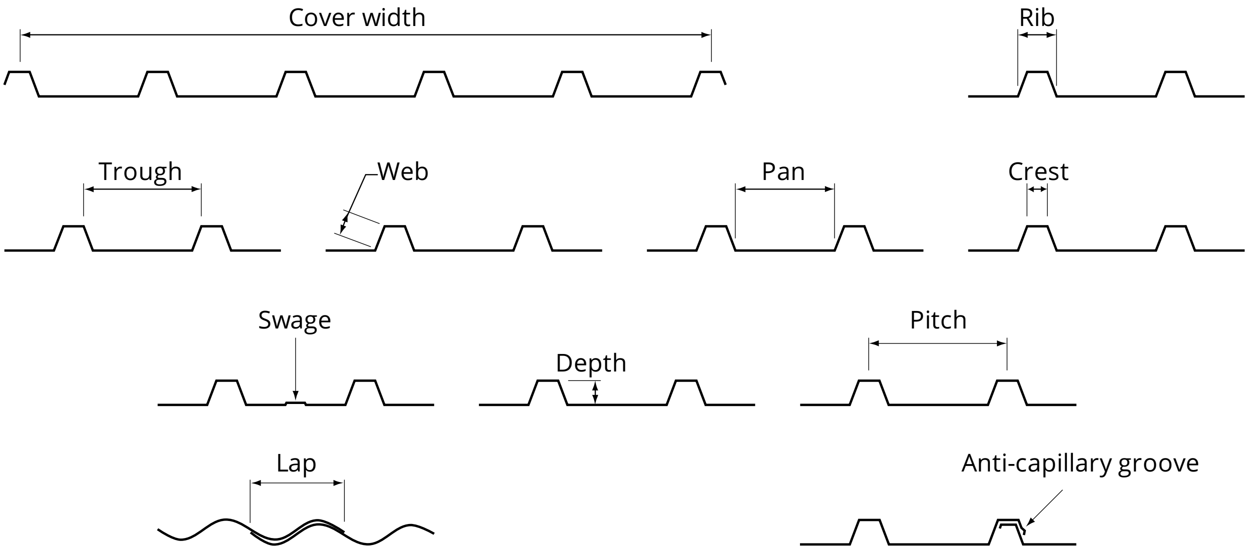
## 2.3A Industrial Detail

## 2.3B Industrial Nomenclature

| | | | |
|---|---|---|---|
| 1 | Apron flashing | 13 | Sill flashing |
| 2 | Hail board | 14 | Door jamb |
| 3 | External gutter | 15 | Vertical cladding |
| 4 | Ridging | 16 | Window jamb flashing |
| 5 | Purlin spacing | 17 | Internal corner |
| 6 | Valley | 18 | Draped curve |
| 7 | Ridge vent | 19 | Curved flashings |
| 8 | Ventilation | 20 | Roll Curving |
| 9 | Barge flashing | 21 | Internal sump |
| 10 | Crimp curve | 22 | Two piece apron flashing |
| 11 | Parapet capping | 23 | Rainwater head |
| 12 | Fascia gutter | 24 | Internal gutter |

# 2.4 Product Geometry

## 2.4A Sheet Profile Terminology



# 3 Structure

*Load Design* discusses design and installation elements to ensure roofs are structurally sound and meet the objectives for the NZBC B1 Structure.

Topics include:

- AZ/NZS 1170:2011
- NZS 3604
- Understanding loads
- Fastener performance
- Profile shape
- Wind load span graphs and fixing patterns.

## 3.1 NZBC Clause B1 (Extract)

Source: New Zealand Building Code Clause B1 Structure

### 3.1.1 Objective

*B1.1 The objective of this provision is to:*

- *Safeguard people from injury caused by structural failure.*
- *Safeguard people from loss of amenity caused by structural behaviour.*
- *Protect other property from physical damage caused by structural failure.*

### 3.1.2 Functional Requirement

*B1.2 Building elements shall withstand the combination of loads that they are likely to be subjected to through construction or alteration, and throughout their lives.*

### 3.1.3 Performance

*B1.3.1 Building elements shall have a low probability of rupturing, becoming unstable, losing equilibrium or collapsing during construction or alteration, and throughout their lives.*

*B1.3.2 Building elements shall have a low probability of causing loss of amenity through undue deformation, vibratory response, degradation, or other physical characteristics throughout their lives.*

*B1.3.3 Account shall be taken of all physical conditions likely to affect the stability of building elements including:*

1. *Self-weight.*
2. *Imposed gravity loads arising from use.*
3. *Temperature.*
4. *Earth pressure.*
5. *Water and other liquids.*
6. *Snow.*
7. *Wind.*
8. *Fire impact.*
9. *Differential movement.*
10. *Influence of equipment services and non-structural elements.*
11. *Time dependant effects including creep and shrinkage.*

*B1.3.4 Due allowance shall be made for*

- *the consequences of failure,*
- *the intended use of the building,*

- *effects of construction activities,*
- *variation in the properties of materials, and*
- *accuracy limitations inherent in the methods used to predict the stability of building elements*

# 3.2 General

The information in this section explains the various factors used in calculating a design loading and in resisting that load.

The designer must be familiar with the performance requirements of the New Zealand Building Code (NZBC). Loads can be calculated in accordance with the appropriate standard and maximum spans and fastening patterns specified according to manufacturers' literature or the generic tables listed in this Code of Practice.

It is the responsibility of the roofing contractor to install roof cladding according to the design and raise any concerns with the designer before commencement.

## 3.3 AS/AZS 1170.2:2011

Roof and wall cladding must structurally comply with the requirements of the NZBC Clause B1 Structure. Strength demand may be calculated in accordance with AS/NZS 1170:2 (which is called the “Loadings Code” in this Code of Practice) or NZS 3604.

Designers should know about changes in requirements of the current Loadings Code and amendments to the code. Manufacturers' printed technical literature, using different criteria or test values and a previous Loading Code's design can cause confusion when it is compared to the latest requirements.

*The Loadings Code identifies four load categories relevant to metal roof and wall cladding.*

- *Wind actions:*
  *Wind loads are the result of local changes in wind speed as the wind flows over and around the building. High positive forces (pressure) apply where the wind is slowed, high negative pressures (suction) apply where the wind accelerates. Wind force varies with the shape and position of the building. It also increases with height because the influence of groundsurface drag decreases.*
- *Permanent action:*
  *Dead load is the permanent weight of the roof structure and the permanent part of an imposed load, such as an air conditioning unit.*
- *Imposed action:*
  *Live loads are variable loads imposed on the building by its occupants and contents, such as a person standing on the roof (point load).*
- *Induced actions:*
  *Loads such as wind, snow or ice, and ponding rainwater.*

When a structure or part of it, fails to fulfil its expected basic functions, it is said to have reached a limit state. There are two limit states—Serviceability and Ultimate.

### 3.3.1 Modes of Failure

Serviceability limit is a state when a building, or any part of it, becomes unfit for its intended use due to deformation or deflection.

Ultimate limit is a state associated with collapse or failure, or when a building or any part of it becomes unstable or unsafe.

These limit states are not limited to the metal roof and wall cladding, but are intended to be applied to the entire building structure.

Because the prime function of metal roof and wall cladding is to exclude water from the structure, irreversible failure at the serviceability limit state, for example permanent distortion around the fastener head, is generally the governing limit state for pierce fastened roof and wall cladding. This Code of Practice treats serviceability as the criterion of failure for pierce fastened roofs, as these failure levels are far lower than those at which ultimate limit state failure is experienced.

## 3.4 NZS 3604:2011

NZS 3604 Timber Framed Buildings  is an acceptable solution to comply with the NZBC for light timber frame buildings not requiring specific design.

It contains prescriptive dimensions for purlin spacing and fasteners, based on maximum design wind speeds of Low (32 m/s), Medium (37 m/s), High (44 m/s), Very High (50 m/s), or Extra High (55 m/s). The load calculations for NZS3604 were based on a simplified interpretation of AS/NZS 1170.  These values can be used for calculation of loads on the cladding of structures designed using NZS 3604.

Some of the limitations in the scope of NZ S3604 are:

- Timber frame construction.
- Height from lowest ground to the highest point on the roof may not exceed 10 m.
- A snow load may not exceed 1.0 kPa, although Section 15 of NZS 3604 does provide additional criteria for 1.5 kPa and 2.0 kPa snow loads.

NZS 3604 includes:

- private dwellings, hostels, hotels and nurse's homes;
- factories with restricted floor loadings; and
- institutional and educational buildings with restricted floor loadings.

NZS 3604 excludes:

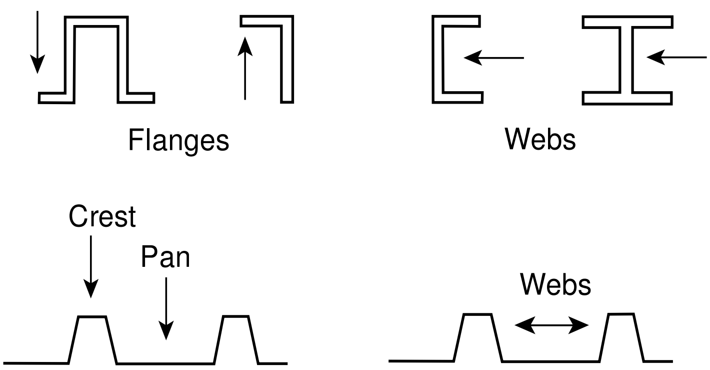
- buildings dedicated to the preservation of human life;
- buildings which may host crowds;
- publicly owned buildings containing high value contents; and
- curved roof construction.

Classification of Wind Zones in NZS 3604 are specific to the site. Because the buildings covered by this standard are limited in size, design tables (but not design wind speed) include a local pressure factor of 1.5 kPa over the entire structure, rather than varying factors according to the position on the roof as required by AS/NZS 1170.

## 3.5 Understanding Loads

The performance of profiled metal cladding under wind, snow and point loads depends on its ability to resist the tension (pulling), compression (squashing), and shear (sliding) forces that it is likely to be subjected to during the lifetime of the building.

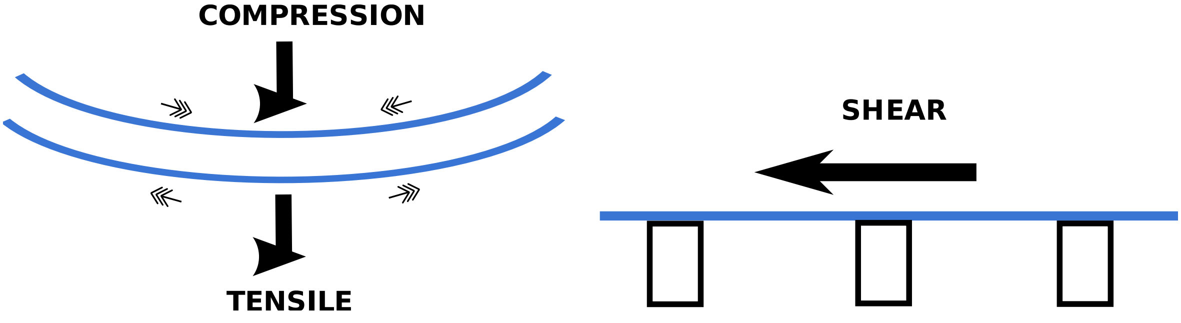
### 3.5A Profiled Steel — Flanges and Webs




*A structural steel member typically comprises of sections named webs and flanges. In a roofing profile the sides of the rib act as a web, and the pan and top of the rib acts as a flange*

*Profiled metal cladding acts as a beam, which derives its strength from the ability of its flanges (pan and the crest), separated by the web to resist tensile and compressive forces. This strength can only be maintained while those parts in compression are restrained from buckling.*

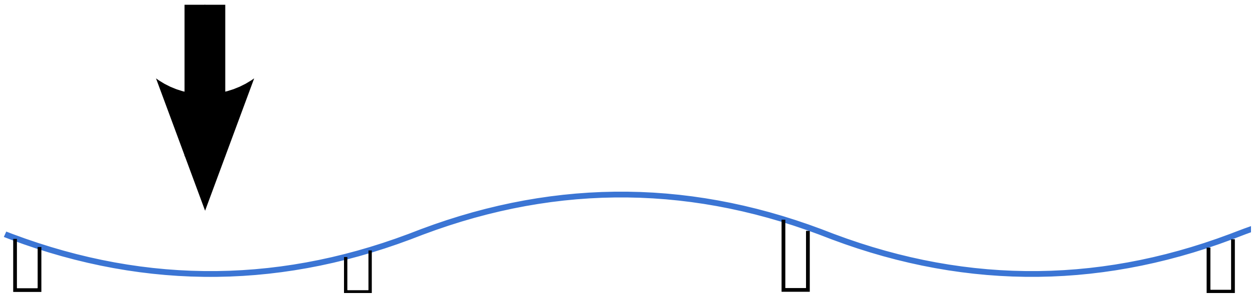
### 3.5B Compression, Tensile and Shear Force




When a beam is subjected to bending, one flange will be under compression and the other under tension.

## 3.5.1
## Point Load

### 3.5.1A Point Load Under Tension



*When a roof sheet deflects downwards under point load, the pan of the profile is placed under tension and the crest under compression, but in the adjacent continuous span, this condition reverses.*
*Metal is relatively strong under tension and weak under compression. Because of this, excessive point load will cause failure by compression buckling of the rib. Wherever possible, temporary point load such as roof traffic should be placed with the weight in the pan of the profile, so that the load is shared by the two adjacent ribs, across two ribs, or at the purlin line. Permanent point load should be placed across multiple ribs.*

### 3.5.1B Typical Rib Damage due to Point Load

## 3.5.2 Wind Load

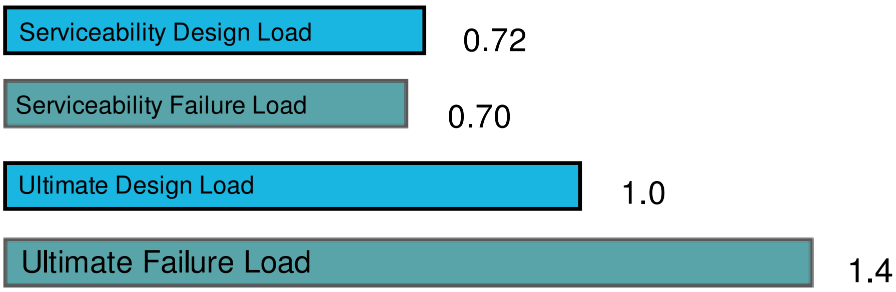
Under wind uplift loading, when all spans of the roof sheet are under upward loads, the crest of the profile is placed under tension and the pan under compression. The deflection and stress patterns are the reverse of those for point load.

### 3.5.2A Wind Uplift Load

Failure under wind load for a clip fastened cladding is usually by the clips de-indexing and the cladding sheets blowing off. This is an ultimate failure.

Initial failure under wind uplift for pierce-fastened cladding is usually local buckling of the rib crest adjacent to the fastener. While the cladding can still resist a load, this permanent deformation is liable to cause leakage at that point; therefore, it is a serviceability failure.

### 3.5.2B Wind Design Load




The design load relates to a specific building and is calculated by the engineer. The failure load relates to a specific product or system and is supplied by the manufacturer. Engineers calculate both the Serviceability load and the Ultimate Load. They compare these values with the maximum failure loads of the products and systems they are considering.

- In design, the serviceability load is no more than 0.72 of the ultimate load.
- In testing, the serviceability load is about 0.5 of the ultimate load for a pierce fastened product.

Therefore, if a product passes for serviceability it will comfortably exceed ultimate design load requirements. In the above example, the product has failed against serviceability but still exceeds ultimate load requirements.

To determine the performance of corrugated and low rib trapezoidal profiles **see 3.16.5 Wind Load Span Graphs**

Refer to manufacturer's load/span tables for all other profiles, which should give the maximum recommended span for end and continuous spans when tested as described in 17.7 Wind and Point Load Testing

## 3.5.3 Deflection

Deflection is a measured deformation of roof or wall cladding under a load, but there is difference between temporary deflection and permanent deformation.

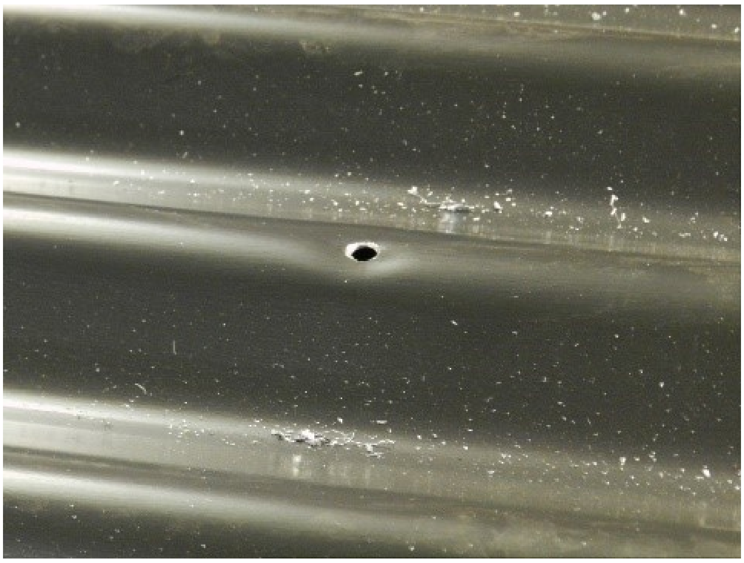
Temporary deflection of cladding under load is within the elastic limit of the steel; the cladding will regain its original shape and strength properties when the load is removed. Permanent deformation that affects the shape, strength or performance of the cladding is serviceability failure.

With high strength claddings deflection failure is often quite sudden and severe once the point of elasticity is reached, but progressive deflection under repeated loads within the material's elastic limit is minimal.

Roof design should consider the effect of repeated loads, when expected, because low-strength steel or non-ferrous metals can progressively yield under wind loads or repeated constant foot traffic. Machine roll-curved, crimp curved cladding, and metal roof tiles are usually made from low strength steels.

### 3.5.3A Deformation Around a Fastener Head

### 3.5.3B Permanent Damage Around Fastener Head



## 3.5.4 Load Distribution

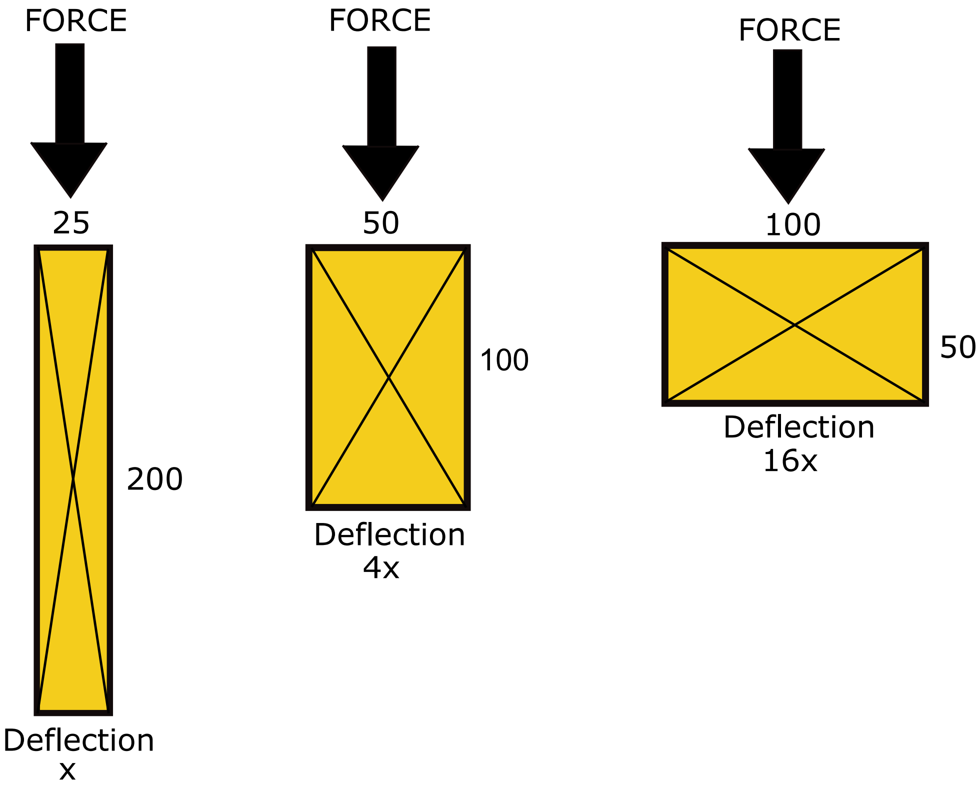
The distribution of the load greatly affects the deflection. A load distributed equally along the length of a beam (line load) will cause less deflection than the same load being applied to the centre of the beam.

### 3.5.4A Little deflection with a line load.

## 3.5.4B Increased deflection with Point Load.


The depth of the profile of metal cladding is another important criterion in the design and use of metal roof and wall cladding. Given the same cross section area, the deflection of the profile will vary with the square of the depth.

### 3.5.4C Deflection and the Square of Depth




## 3.5.5 Yield Strength

Yield strength is the point beyond which material will permanently deform, and Ultimate strength is the point beyond which the material ceases to resist load. Yield strength is affected by the type, grade or temper of the metal measured in Megapascals (MPa). The yield point is more important than the ultimate strength when designing and using metal roof and wall cladding.

The yield point of any metal can vary depending on the temper. If the yield point is higher, it is possible to reduce the thickness of the metal of the same profile and still obtain equal performance.

## 3.5.6 Section Properties

*Various attributes or effects can be identified by looking at individual shapes or profiles of metal cladding, but their performance cannot be accurately determined by their section properties as their profile shape, and therefore the sectional properties, change during deflection.*

*Corrugated iron is a common profile traditionally used in roof and wall cladding. It has a symmetrical sinusoidal profile and is equally strong under positive or negative loading. Its 'neutral axis" runs through the centre, or halfway-depth, of the profile. Symmetrical trapezoidal profiles have similar attributes.*

*Symmetrical corrugate or trapezoidal profiles have the advantage of being more easily curved around a radius. Because the ribs are necessarily close together, they have the disadvantage of roof traffic loads having to be spread over two crests or along the purlin line, and they have a lower run-off capacity.*

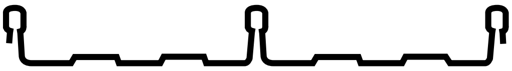
### 3.5.6A Symmetrical Profile

Symmetrical Trapezoidal

Corrugate

### 3.5.6B Asymmetrical Profiles

Asymmetrical Trough



Asymmetrical Trapezoidal

*Most profiles fixed on non-residential roofs in New Zealand are asymmetrical trapezoidal or ribbed profiles, with ribs formed at various spacings and different heights. The angle and height of the trapezoid rib determines the profiles performance under compression. A steeper angle generally gives improved performance, but raises cost per square metre as it lowers sheet effective coverage.*

*The rib spacing determines the position of the neutral axis, which is the point of zero stress. Bigger spacing between the ribs lowers the neutral axis.*

*Roof cladding should be designed to withstand both positive and negative design loads. Profile designers use computer software to compare the "moment of inertia" (deflection) and "section modulus" (strength) to find a compromise in different profiles.*

*Strength and deflection are interrelated but not interdependent, and the design strength is determined by the stress (f) at which permanent deformation occurs. Stress is determined by the section property known as the Modulus of Section (Z). Although it is possible to calculate the sheeting performance from the section properties of the profile, only physical testing can prove the actual capabilities of the profile.*

*Deflection under load depends on the profile section dimensions or section properties, and it is determined by the Moment of Inertia (I) and Young's Modulus (E). Various metals have different E-values, which means the same cladding profile made in aluminium will deflect more than steel. See 17.3* ***General Methods Of Testing Sheet Roof And Wall Cladding.***

*The strength or grade of the metal does not affect the deflection. A high-strength steel profile will deflect to the same extent as low-strength steel profile, but using high-strength steel will increase the point at which yielding or permanent damage occurs. See 13.6* ***Walking On Roofs.***

## 3.5.7 Fatigue

The performance of metal roof and wall cladding is affected by stress as all metals may be subjected to fatigue under repeated heavy load conditions.

Metal cladding can fail at a much lower point than the yield stress when there is movement under continued fluctuating stress. A cyclic load test is used to determine the performance of cladding under load reversal.

All metal joints will suffer stress because of movement caused by expansion, vibration, traffic or wind. A sealed joint should have enough fasteners to mechanically resist this stress, because sealant or solder alone do not offer enough resistance. Load spreading washers are used in areas subjected to high wind design loads to give greater resistance to any stress-cracking at fixing holes.

High-strength steel is subject to fatigue, which seldom happens in practice. Other metals, such as lead and copper, are restricted in length or the overall panel size to avoid cracking by fatigue. Sharply folded corners should be avoided on these materials and the minimum radii requirements should be followed.

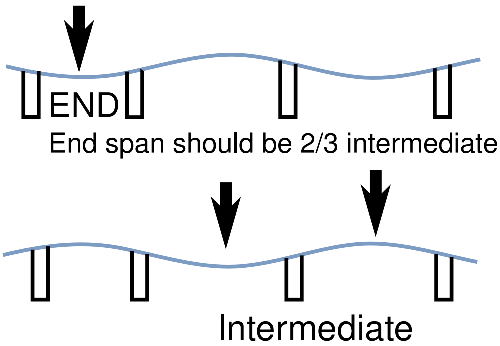
## 3.5.8 Continuity

*It is important to understand the relationship of strength and deflection when using multiple span profiled metal cladding, because the performance of roof cladding under load depends on the continuity over several spans.*

*An adjacent continuous span assists the performance of profiled metal cladding, as continuity can reduce deflection up to 50%. In single spans the cladding is free to rotate at each support, but with continuity at a support the cladding is held down by an adjacent span; reducing the rotation and midspan-deflection.*

*Profiled metal sheeting deflects less over intermediate spans because it has continuity at two ends, unlike the end span, having continuity at only one end.*

### 3.5.8A Continuity




*Tests for point load have established the ratio between the end span length and the intermediate span length, when both spans will fail at approximately the same load.*

The end span of profiled metal cladding should be no more than two-thirds of the intermediate span for optimum performance under both point load and wind load. Neglecting to do this can lead to failure of the end spans when are they subjected to foot traffic.

The endspan condition occurs at the eaves, ridge, roof steps and on both ends of penetrations where a full width sheet is cut. Cladding around penetrations may need additional purlin support, spaced at an equal distance to the endspan spacing.

# 3.6 Types of Load

Loads acting on roof cladding are generally classified into two types: point load and uniformly distributed Load (UDL)

Cladding reacts differently to a point load and a UDL. A point load is applied to a particular area, but a UDL impacts on the total area of the roof.

In many cases the point load will govern; it is often the most severe of the actions and will determine the purlin spacing of roof sheeting. Uniformly distributed loads vary over the roof area. They are greatest at the periphery and corners of a structure. Purlin spacing may have to be reduced, or the fastener frequency increased, to cope with local pressure factors.

Manufacturer's roof and wall cladding design load data should be published with both point and UDL performance values.

## 3.6.1 Point Load

Most roofing profiles will resist far greater point loads when the load is applied to the pan of the profile rather than the rib. When the load is applied to the pan, the load is shared by the adjacent ribs and is applied to the flange under tension, rather than the flange under compression.

Testing loads may be applied to the pan or the rib depending of the profile shape and the design criteria. See 3.6.2 Roof Traffic.

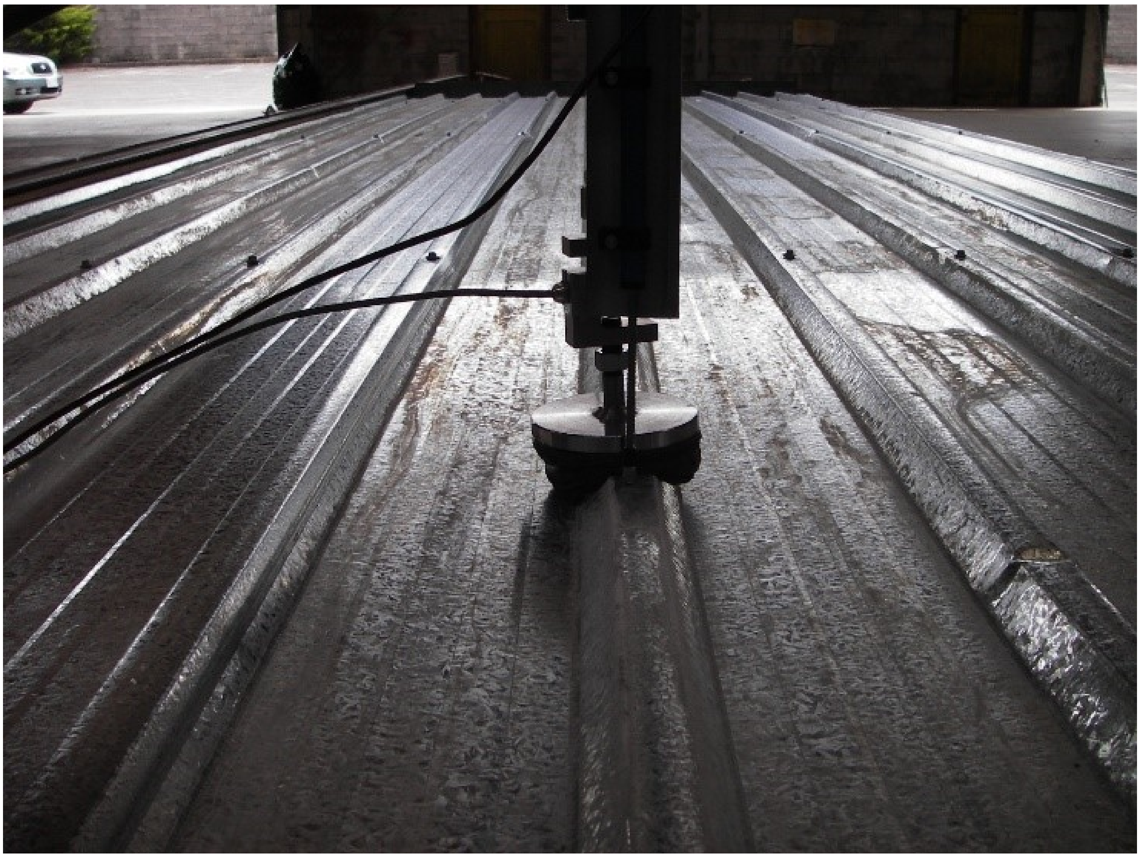
Roofs that may be accessed by foot traffic must be designed to withstand a point load which is representative of a workman with a bag of tools. It is calculated at 112 kg, which equals 1.1 kN force.

In the case of a superimposed load, such as an air conditioning unit which is supported directly by the roof cladding, the unit weight per support and area of contact is calculated to arrive at point loads.

A point load on a roof is always positive or downward (+).

3.6.1A Point Load Test at the MRM

## 3.6.1A Point Load Test at the MRM



## 3.6.2 Roof Traffic

The designer must consider the degree and type of foot traffic that may be expected on a roof. The following requirements are subjective standards and must be considered in line with customer expectations, and building use and type.

More robust design than specified below (reducing purlin spacing or adding protection from mechanical action), is required for:

- roofs that are regularly accessed; and
- roofs used as staging by subsequent trades; or areas that are adjacent to access points, particularly step down access.

Type A (Unrestricted Access) will comply for roofs:

- that need to be regularly traversed by the roofer for access during installation;
- that will be accessed regularly by sub-trades;

- that butt on to walls or windows that may require maintenance;
- that have plant, chimneys, or solar installations requiring regular maintenance; or
- that require regular access for clearing gutters or spouting of debris.

For Type A roofs, the cladding must resist the load of 1.1 kN applied to the pan or a single rib.

Type B (Restricted Access) will comply for roofs:

- that are simple in design and do not have to be regularly traversed by the installer;
- which are infrequently accessed by qualified tradesmen for maintenance; or
- with a pitch of more than 35°.

For Type B, roofs the cladding must resist the load of 1.1 kN applied to the pan or over two ribs.

Type C (Non-trafficable) will comply for roofs:

- where supports are required to be laid to support roof traffic;
- which have a pitch of 60° or greater; and
- including non-trafficable translucent roof sheeting.

For Type C roofs, the cladding must resist the minimum load of 0.5 kN applied to the pan or over two ribs.

## 3.6.3 Unformly Distributed Action (Wind or Induced Action)

*A UDL is commonly either a wind load or a snow load. These loads are variable and depend on factors such as the location, topography, and position on the structure, but do not often exceed 6 kPa. The most severe wind load is usually an uplift load, or negative (-), and snow load is a downward load or positive (+).*

# 3.7 Wind Load

The wind load imposed on a roof structure is taken to apply perpendicularly to the roof cladding over a nominated area. The design wind load is affected by the pitch of the roof and is modified using factors called pressure coefficients. Wind design load is measured in kilopascal (kPa); 1 kPa equals 1 kN/m².

AS/NZS 1170.2 and NZS 3604 contain the basic wind speed regions for New Zealand and the modifying factors that govern the design wind load. The predominant wind speed for New Zealand is 45 m/s. The exceptions are either side of Cook Strait and areas in the lee of mountainous areas.

## 3.7A Sheltered Building

*Scattered obstructions of a similar height or lower within 500 m from a building will considerably lessen wind speeds and lower design wind pressures.*

## 3.7B Unsheltered Building


*Structures in open land such as flat pasture and playing fields, or by water, will be subjected to higher design wind pressures.*

## 3.7C Topographical Influences

*Terrain also has a big effect. Structures near the crest of a rise or on flat land near a steep face will have increased design wind pressure.*

Wind Design Load is affected by building design factors such as building height, shape, proportions, orientation, and roof pitch. Permeability can also be a big factor. Buildings with large openings on one side but completely closed on the other three sides will suffer high internal wind pressures. These internal pressures must be added to the suction load on the outside of the roof when calculating wind design load.

Local territorial authorities are usually able to give wind speed figures for a specific address in their area. All other factors, including topographical influences, internal, and local pressure factors must be considered by a suitably qualified professional to calculate the design wind load on a structure.

## 3.7.1
## Local Pressure Factor (Kl)

The local pressure factor (Kl) is an important design consideration required by the Loadings Code. The peripheral areas of roof and wall surfaces are subjected to greater uplift loads than the main body of the roof. Designers need to include local pressure factors in the calculation of wind loads on the cladding.

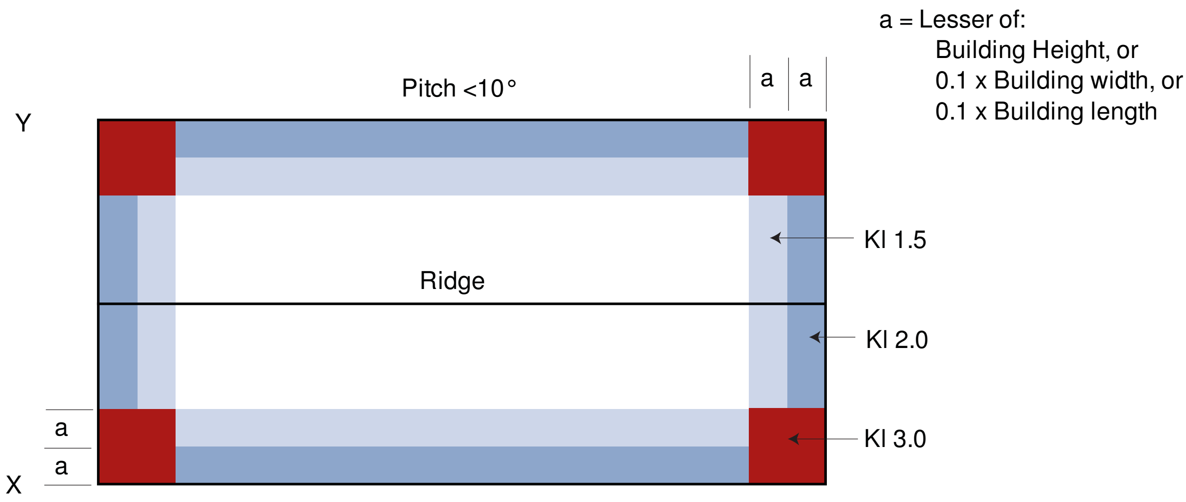
When determining fixing requirements, the engineer must prepare a roof map showing purlin spans and local pressure factors for each section of the cladding. See 14.6.3A Pull-Over.

When designing to NZS 1170 the local pressure factors are:

- 1.5—applied to the edges of all buildings at a dimension equal to 0.2 or 20% of the width or height of the building whichever is the least.
- 2.0—applied to the edges of all buildings at a dimension equal to 0.1 or 10% of the width or height whichever is the least.
- 3.0—applied to roof pitches less than 10°, at the corners where the dimensions in (a) intersect. It also applies to corners of walls where the building height is greater than the building width.

## 3.7.1A Local Pressure for Low Pitch Roofs

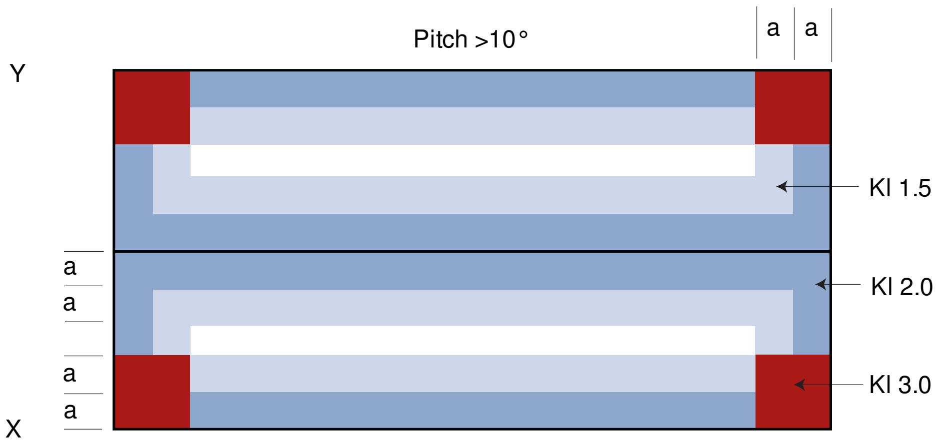
**Local Pressure (Kl) factors as per AS/NZS 1170**




Pitches below 10° do not have local pressure factors at the ridge

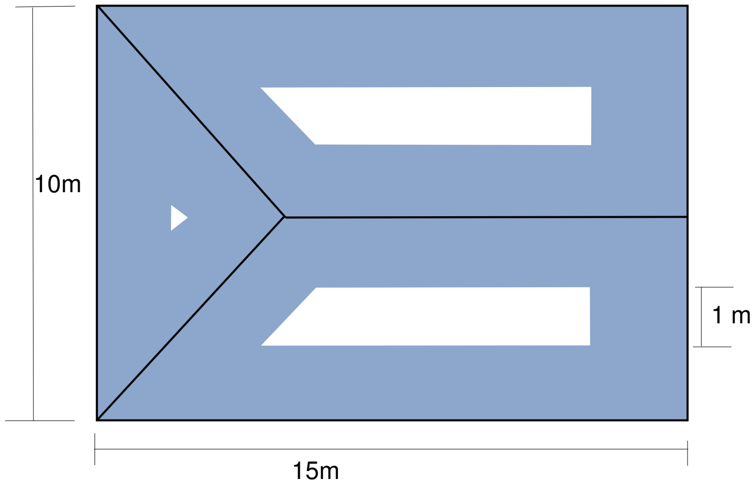
## 3.7.1B Local Pressure Factors for Roofpitch over 10°

**Local Pressure (Kl) factors as per AS/NZS 1170**




On smaller roofs the local pressure factors comprise a sizeable portion of the roof, especially where pitch exceeds 10 degrees.

## 3.7.1C Local Pressure Factors C




Periphery area = .20 x width
Area of roof 150m²
Peripheral area 132m² = 88%
Length of internal area = 1.000

## 3.7.2
## Conversion of Wind Speed To Pressure

The basic formula for converting a wind speed to wind load is: 0.6 x $velocity^2$= wind load.  However, to get a true design wind speed is a lot more complex; various factors have to be applied including roof self-weight, internal pressure and local pressure coefficients.

The most influential of these factors is generally the local pressure factor, but internal pressure can also have a profound influence—particularly on unlined structures. Even houses built to NZS3604 have internal pressure factors incorporated into their design load calculations.

## 3.7.3
## Roof Weight

The self-weight of light-weight profiled sheet cladding should be included in the calculation of net wind load, but is a minor factor.

# 3.8 Snow Loads

Roof cladding design does not usually have to be altered for snow load, but it may be necessary to increase the strength of the structure to allow for induced snow loads.

The maximum snow load in New Zealand (under NZS 3604) is a UDL of 2 kPa. Collapse under snow load would be a strength failure, since 2 kPa is less than the upwards load in a Very High Wind Zone. However, as it is a downwards load, restraint is linear by the purlins, rather than point restraint by the fasteners, so greater capacity is achieved.

Any profile-gauge combination that will resist a wind load of Very High or Extra High Wind Zone with fasteners at each crest, will adequately resist a 2 kPa snow load.

*New Zealand is divided (in NZS 3604) into six zones where the maximum snow load is 2 kPa. Any areas above specific altitudes in these areas require specific design. Buildings designed according to NZS 3604 are designed to withstand a 1.0 kPa snow load. Buildings above a given altitude in areas 1 – 5 (see 3.8A Snow Loadings Map) must be designed to withstand the appropriate snow load.*
*Projections such as gutters, flashings and chimneys need additional fixings and detailing to resist loads from sliding snow. Doorways must be easy to keep clear.*

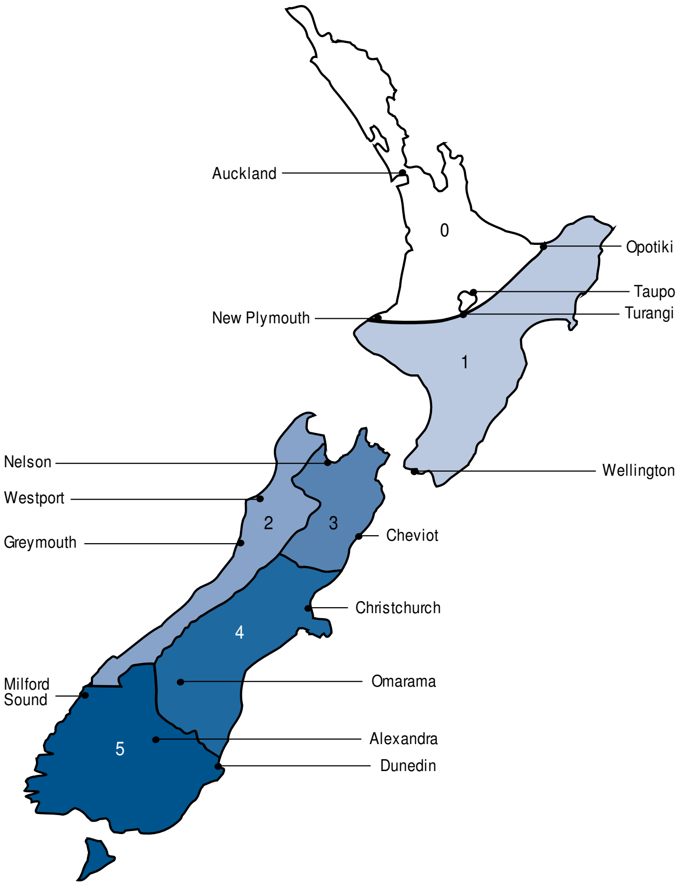
## 3.8A Snow Loadings Map

## 3.8B Altitudes for Specific Design

**Snow Loading Allowance is not required for Zone 0**

| Zone | Up to: | 1.0 kPa | 1.5 kPa | 2.0kPa |
|---|---|---|---|---|
| 0 | | Not Required | | |
| 1 | | 400 | 600 | 850 |
| 2 | | 400 | 600 | 850 |
| 3 | | 400 | 600 | 850 |
| 4 | | 100 | 200 | 350 |
| 5 | | 200 | 300 | 400 |




## 3.9 Dead Loads

Any permanent load added to the roof cladding or structure is termed superimposed; that includes air conditioning equipment, solar installations, television aerials, anchor points and walkways.

**All permanent loads must be fixed to or through the rib of the cladding profile or directly to the primary structure. The rib, even at the purlin line, has limited capacity for an additional load and the roof cladding must be free to expand.**

**Any attachment to the roof cladding must be compatible with the cladding.**

## 3.9A Correctly Installed Permanent Load

An air conditioning unit correctly installed on a roof, using durable and compatible materials.

**No additional equipment must be directly connected to the cladding without considering the effect of increased dead and live loads.**

**When designing installations for placement on the roof, the roof traffic implications of installing and servicing such must be considered when determining point load resistance requirements**

## 3.10 Construction Loads

Construction loads on a building include the wind load on a partially clad or braced roof or building. Depending on the method and sequence of construction, it can be greater than the load on a completed building.

Other forces contributing to construction load include:

- The intensity of internal wind pressures due to a temporary absence of ceilings, walls and glazing.
- Storage of roof cladding on the structure. Bundles of roof cladding should be placed so they do not cause overstress in purlins.
- Any scaffolding above an existing roof must be designed to avoid damage to the roof structure or coatings.

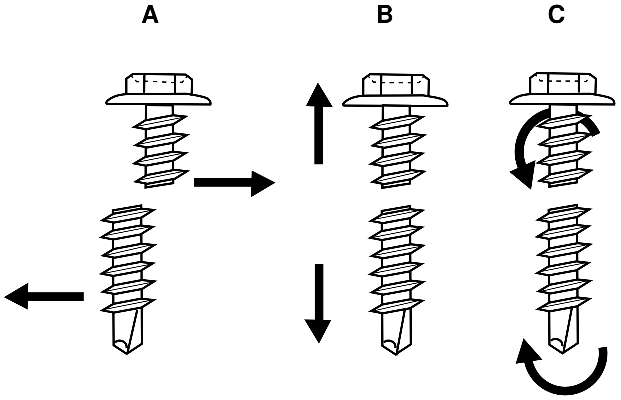
## 3.11 Fastener Loads

Fastener design aims to avoid strength failure of the screw before failure of the sheeting or the structure. Most fastener failures happen due to negative load (or uplift) and testing procedures are designed to closely simulate these conditions.

Fasteners used to fix metal cladding can fail by pulling out of the structure or by shearing. The cladding can fail by pull-over or profile collapse.

Fastener design should be sufficient to avoid pull-out and prevent deformation of the cladding around the fastener heads that can cause leaks.

### 3.11A Fasteners – Mechanical Properties




A. Single Shear Strength (N)
The shear load required to break the screw

B. Axial Tensile Strength (N)
The tensile strength to break the screw

C. Torsional Strength (Nm)
The torque required to break the screw

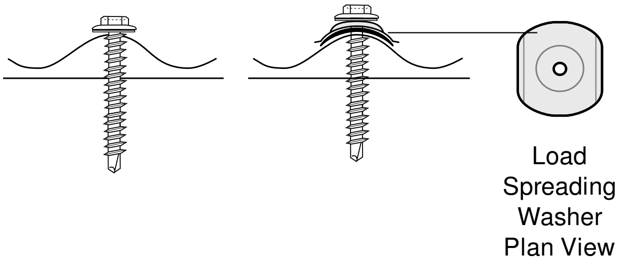
## 3.11.1 Load-spreading Washers

Profiled load-spreading washers spread high wind uplift-loads over a larger area around the fastener head. Using load spreading washers under the fastener can increase the load resistance of each fastener by up to 50%.

The type, size and stiffness of washers are critical for performance. Where performance data incorporating load-spreading washers is used, the specification of the washer must be quoted with the fastener.

In general, load-spreading washers should have a minimum thickness of 0.95 mm for steel and 1.2 mm for non-ferrous metal.

## 3.11.1A Load Spreading Washers




Where oversized holes are used to accommodate thermal movement of the sheeting, load-spreading washers should be used with sealing washers to ensure weather tightness.

# 3.12 Fastener Performance

Most fastener failures happen due to negative load, or uplift conditions, and testing procedures for fasteners are designed to closely simulate these conditions.

If every rib has a fastener, the only way to improve performance is to use load-spreading washers under the fastener heads, or place purlins closer together.

## 3.12.1 Screw Fasteners

A fastener penetration of three threads through the steel member is sufficient for the fastener to meet its full design capacity. Pull out failure is not normally a risk with high tensile steel purlins over 1.1 mm in thickness.

### 3.12.1.1 Steel Purlins Thinner Than 1 mm

The pull-out values of screws into light gauge steel battens or purlins varies greatly with thread design, pitch and drill point shape. Pull out can be the mode of failure of light gauge steel battens depending on the cladding profile and the fastener design. When fastening into battens less than 1.1 mm in thickness, the pull-out values of the specified screw must be considered and the installation must be completed with that type, gauge and brand of screw. In light gauge steel, it is important to avoid stripping out the formed screw thread, therefore a depth setting screw gun is recommended.

### 3.12.1.2 Steel Purlins Thicker Than 1 mm

A fastener penetration of three threads through the steel member is sufficient for the fastener to meet its full design capacity. Pull out failure is not normally a risk with high tensile steel purlins over 1 mm in thickness.

### 3.12.1.3 Timber Purlins

Timber purlins generally require a fastener penetration of 30 mm. With this level of embedment, a screw equipped with a profiled washer though 0.55 material will fail by pull-through of the cladding before it fails by fastener withdrawal from the timber. Greater thicknesses of cladding may require specific design. For fastening into sarking or rigid air barrier less than 30 mm thick, the pull-out values for the specific screw and sarking material should be obtained from the supplier and required fastener pattern calculated.

## 3.12.2 Pull-over Values

*When metal cladding is subjected to uplift wind loads within the withdrawal capacity of the fastener, the failure mode will be pull-over or pull-through. The pull-over value is determined by the thickness and strength of the metal and the area over which the load is spread. See 3.12.2A Typical Pull over values for crest fixing (serviceability failure).*

*If the pull-over load is likely to be exceeded, the options are to increase the metal thickness or use a load-spreading washer. The pull-over value when using 0.70 mm aluminium is approximately the same as 0.40 mm steel.*

*Pull-over load depends on the head or washer size. For example, as 12# and 14# screw heads have approximately the same diameter, these screw sizes have the same design load value for pull over.*

*The pull over values for pan fixing cladding are higher than those obtained by crest fixing by a factor greater than 2, depending on the screw's position in the pan. See 14.5.2 Pan Fixing.*

## 3.12.2A Typical Pull over values for crest fixing (serviceability failure)

| *Thickness (mm)* | *Screw Only (kN)* | *Load Spreading Washer (kN)* |
|---|---|---|
| *0.40* | *0.4* | *0.7* |
| *0.55* | *0.5* | *0.9* |

## 3.13 Material Grade

The most significant strength characteristic of metals used for profiled metal roofing is the tensile strength. To test for tensile strength the material is subjected to a longitudinal (stretching) load, and values are taken for yield strength (when it permanently deforms) and tensile strength (when it breaks). Elongation is also measured during this test.

The minimum tensile strength defines the grade of steel, eg, G550 for high strength light gauge steel, but to comply with this grade the yield strength and elongation must also fall within defined parameters. For G550 material, the minimum yield strength requirement is the same as the tensile strength, but for more ductile grades the yield strength requirement is lower.

Tensile strength is an important determinant of the strength of a profile, along with profile shape and material thickness. High tensile material will have more resistance to failure such as buckling around the fastener under wind uplift, pull through of the fastener head or buckling under foot traffic[MS1] load. However, tensile strength has a negligible effect on deflection under load.

When 0.55 material is specified for straight corrugate or trapezoidal roofing, it is unacceptable to substitute G300 for G550 grade material as the resultant profile will have little strength advantage over 0.40 mm G550.

Aluminium is defined by a hardness grade ranging from H32 to H38. Typically, H34 is used for flashings, severe profiles such as trough sections and profiles that are to be curved. Most corrugated and Trapezoidal profiles are manufactured using H36.

It must be remembered that the alloy also affects strength. H36 aluminium in 5005 or 5025 alloys, which are typically used in New Zealand, will have considerably greater tensile strength than the same grade in a 3000-series alloy.

### 3.13A End Use for Typical Alloys

| Material | Grade | Typical End Use |
|---|---|---|
| Steel | G300 | Flashings, ridging, spouting, curving, some trough sections. |
| | G550 | Corrugated and trapezoidal profiles, some trough sections. |
| Aluminium 5505/5025 | H34 | Flashings, ridging, spouting, curving, trough sections. |
| | H 36 | Corrugated and trapezoidal profiles. |

## 3.13B Tensile Testing

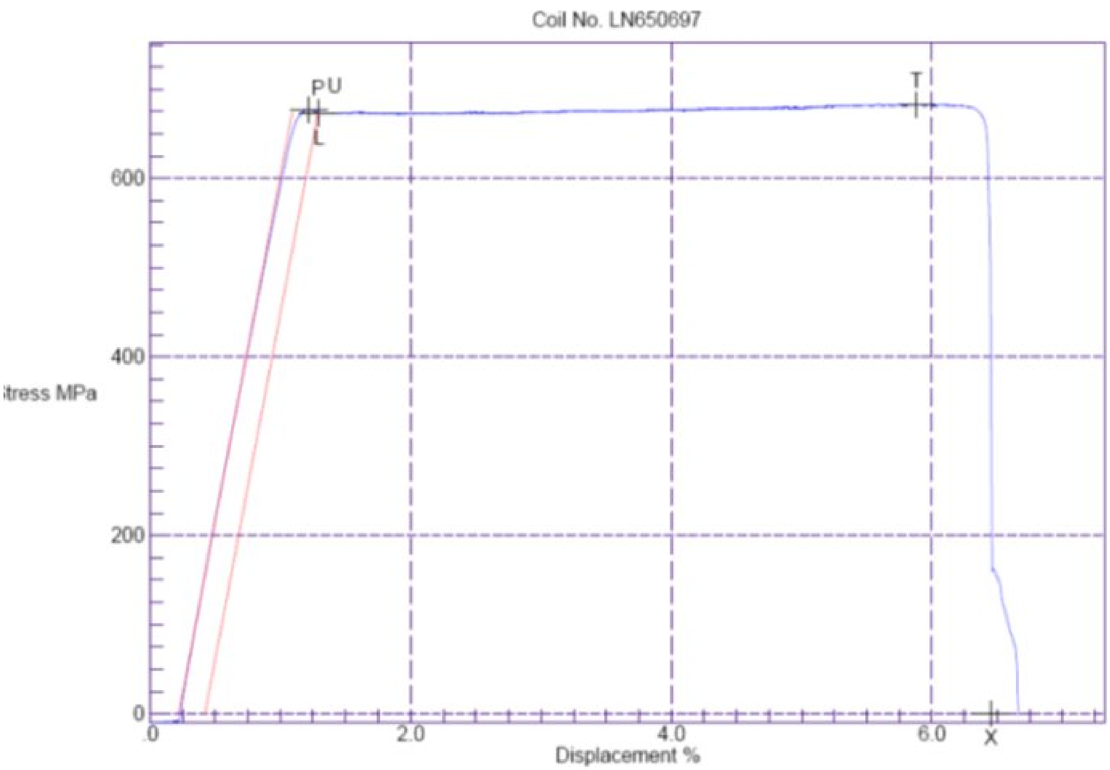
## 3.13C Typical Result for G500 Steel

NEW ZEALAND STEEL - TECHNICAL SERVICES LABORATORIES

*** TENSILE TESTING RESULTS ***

DATE: 08/03/2007 SHIFT: D MACHINE: Instron 5882 TESTER: GT LAB REF No.: AX374

| Reference (Comments) | Status Code | Dir/ Pos | DIMENSIONS Thickness Nom. mm | Act. mm | Dev. % | Width mm | Length mm | RESULTS UYS MPa | LYS MPa | PRF MPa | T'SL MPa | YE % | UE 10% % | UE 15% % | UE Tot % | TE % | R | Type | Y/T | Rate E-3 /s | H'ness R'well | Miscellaneous Result | EXT | XMT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LN 650697 | | LC | 0.000 | 0.440 | 0 | 12.48 | 77.00 | 677 | 673 | 673 | 683 | | | | | 8.4 | | E | .99 | 0.8 | 82B | No Check | 0 | T |



# 3.14 Material Thickness

Material thickness has a great bearing on strength. For residential buildings, 0.40 thickness material is most commonly used for corrugated and trapezoidal profiles, and this will normally be sufficient to withstand the statutory wind loads at typical spans and fastener spacings in up to High Wind Zones. In higher winds speeds, fastener patterns may have to be increased or purlin spacings decreased to accommodate wind loads (see 3.7 Wind Load) or thicker materials can be used.

Material with a 0.40 thickness is, however, very vulnerable to foot traffic damage in most profile configurations and requires careful and accurate foot placement to avoid buckling. In residential buildings with high foot traffic expectancy or highly visible roofs, eg, multi-level mono pitch roofs, roofs with UV collectors, flues, aircon devices or chimneys that need servicing, or prestige housing 0.55 material should be selected.

For commercial and industrial applications, 0.55 is almost universally used on the roof, and 0.40 or 0.55 on the walls.

0.40 and 0.55 are not the only thicknesses available; 0.48 is often used for high tensile trough sections, where it will often compare in strength to similar profiles manufactured from 0.55 G 300 material. 0.75 is often specified for heavy duty industrial roofs, and 0.63 is often manufactured for the Pacific Islands and other hurricane-prone regions. Other thicknesses are also available subject to minimum order quantities

G300 at 0.55 is the most common specification for spouting, flashings and ridging.

## 3.15 Profile Shape

The geometry of the profile shape determines the strength performance of the profile. Variation of profile shape from that tested will produce different results under load in pierced fastened profiles and may produce vastly different results in clip fixed profiles.

### 3.15.1 Corrugate Profile

The corrugated profile has been used in New Zealand for over 150 years and there has been only one significant change during that period. In the 1960s the steel grade used for roof and wall cladding changed from low-strength steel (250MPa or G250) to high-strength steel (550 MPa or G550). The number of corrugations also changed from 8 to 10.5, which enabled the sheets to be laid either side up, as opposed to over-and-under.

The performance of high strength steel corrugated cladding under point and wind loads is much higher than the more ductile grade (G300) still used for machine curving. G300 material of 0.55 mm has the same strength as 0.40 mm high-strength (G550) material; designs using G300 should take the lesser strength into account. G300 material should not be used in lieu of G550 unless there is good reason to do it.

Mixing the two grades of corrugate profile should be avoided when possible. If they are used on the same job, particularly when they are overlapping, the manufacturer should adjust the profile shape to provide an acceptable fit.

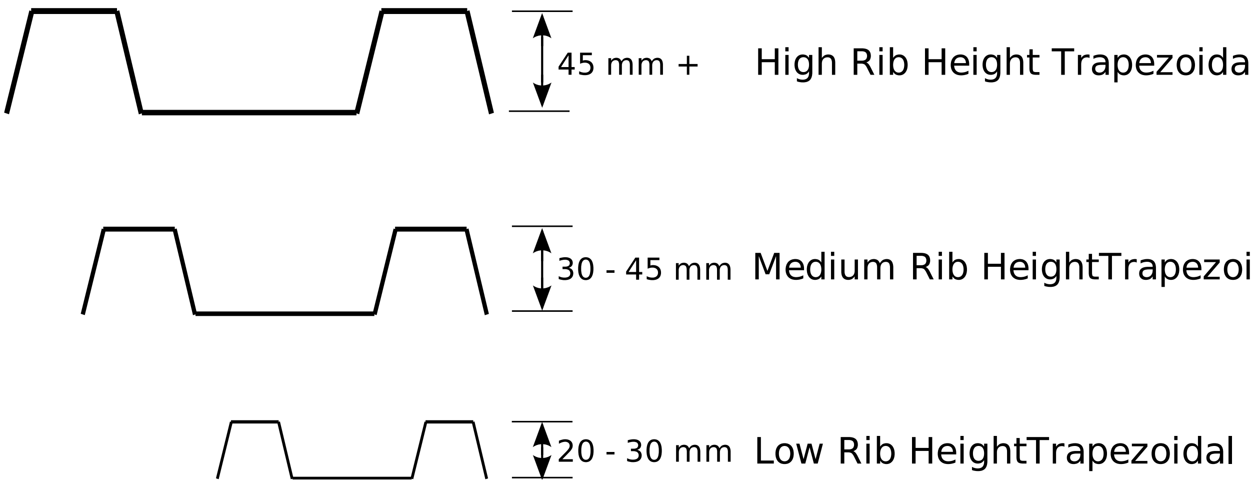
Corrugate cladding is formed with a slightly asymmetrical overlap profile to a capillary barrier.

### 3.15.2 Trapezoidal Profile

The trapezoidal shape provides a greater water carrying capacity and provides greater spanning capabilities than corrugate (sinusoidal) profile. For nomenclature or description of the parts of the sheeting used in this COP, see 2.4 Product Geometry

The maximum available fastener density (fastener per square metre) on deep trapezoidal cladding profiles is usually lower than on corrugate, because of the wider rib spacing and longer spanning capability of stronger profiles.

## 3.15.2A Trapezoidal rib heights




## 3.15.3 Miniature Profiles

Various miniature cladding profiles are manufactured in New Zealand, the most common being known variously under the names of mini-corrugate, sparrow iron, baby iron and mini-iron.

Mini-corrugate is sometimes used for small roof areas, such as spires and awnings. It is most commonly used for wall cladding, parapets and internal linings where studs are normally spaced at 600 mm centres. The accuracy of the framing will determine the quality of finish obtainable.

Mini-corrugate has been produced in New Zealand for many years to the imperial measurement of 1" pitch and 1/4" height, which converts to 25.4 mm x 6.3 mm in metric measurement.

Some miniature trapezoidal profiles are also manufactured specifically for wall cladding.

# 3.16 Maximum Span and Fastener Requirements

## 3.16.1 Purlin-Rafter Connections

For sprung curved roofs, the purlin/rafter connection must be increased at the eaves.

Long lengths of pierce fixed roofing will impose added loads to the purlin connection due to thermal movement of the roof.

### 3.16.1A Purlin to rafter fastener requirements for SG8 Radiata pine, complying with NZS 3604:2011

| | |
|---|---|
| (blue) | **Use 70 x 45 mm radiata pine on flat minimum** |
| (red) | **Use 90 x 45 mm radiata pine on flat minimum** |

| Rafter Spacing | Purlin Spacing | Low Wind Zone | Medium Wind Zone | High Wind Zone | Very High Wind Zone | Extra High Wind Zone |
|---|---|---|---|---|---|---|
| 0.9 | 0.6 | A | B | C | C | C |
| 0.9 | 0.9 | B | C | C | C | D |
| 0.9 | 1.2 | C | C | C | D | D |
| 1.2 | 0.6 | B | C | C | C | C |
| 1.2 | 0.9 | C | C | C | D | D |
| 1.2 | 1.2 | C | C | D | N/A | N/A |

### 3.16.1B Purlin to Rafter Fastener Fixing Capacity

| Type | Fastener | Fixing Capacity (kN) |
|---|---|---|
| A | 1/90 x 3.15 gun nails | 0.55 |
| B | 2/90 x 3.15 gun nails | 0.80 |
| C | 1/10g x 80 mm self-drilling screw | 2.40 |
| D | 2.10g x 80 mm self-drlling screws | 3.45 |
| E | 1/14 g X 100 mm self-driling screws | 5.50 |

## 3.16.2 Sheet Overhang

The maximum overhang for all corrugate and low trapezoidal profiles is 150 mm, unless a product has been specifically tested to withstand point load and design wind loads at a greater overhang.

The allowable overhang distance of various cladding profiles will depend on their section properties.

*When using trapezoidal profiles, greater overhangs can be achieved by stiffening the edge of the sheet in various ways; the most common being using a square gutter with a horizontal flange, but this should be fastened on every pan to achieve continuity.*

The limit placed on low trapezoidal profiles with a stiffened overhang is 300 mm but it is not suitable for corrugate.

The overhang distance can be increased for some trapezoidal profiles with a rib height greater than 28 mm, but this distance must be proved by testing.

Where the cladding is fixed at a ridge or apron, the overhang distance can be increased to 250 mm from the end of the sheet, as the cladding is not subjected to the same point load or UDL and the load is shared with the flashing.

Point of access and expected roof traffic loads must also be considered.

## 3.16.3
## Maximum Spans for Corrugate Wall Cladding

The maximum span for pan fastened wall cladding is generally governed by temporary deflection under load, rather than permanent deflection around the fastener.

### 3.16.3A Maximum Span for Wall Cladding: 5 Fasteners per Sheet (every second trough)

*Serviceability load governs

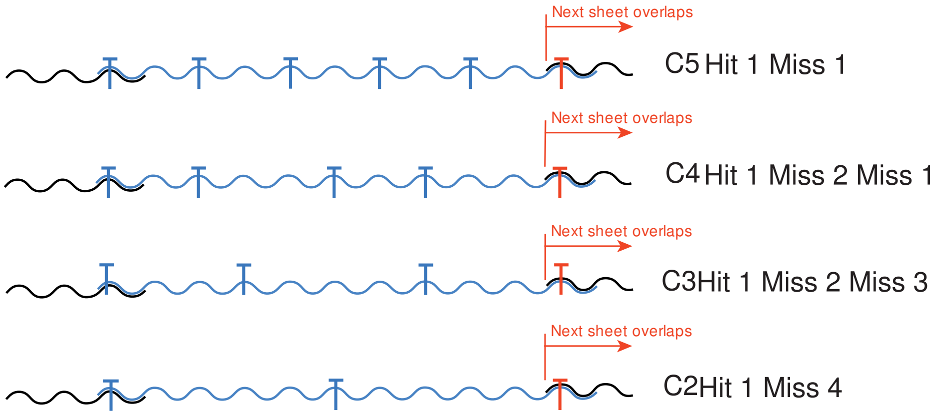
The deflection criteria used in this table is span/120 + P/20, where P = the space between fasteners. Higher deflection limits may be acceptable in certain circumstances.

| Wind Zone | Load (kPa)* | Maximum Spans | |
|---|---|---|---|
| | | 0.40 mm | 0.55 mm |
| Medium | 0.93 | 1.80 | 2.10 |
| High | 1.32 | 1.50 | 1.80 |
| Very High | 1.72 | 1.40 | 1.60 |
| Extra High | 2.09 | 1.20 | 1.50 |

## 3.16.4
## Fastener Patterns

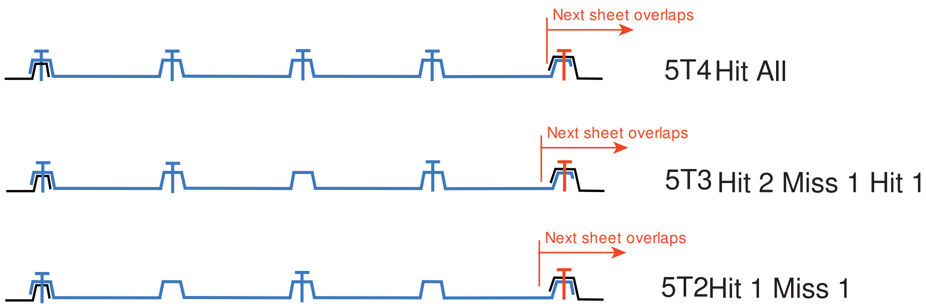
Fastening patterns for the most commonly used profiles are designated in the following manner.

## 3.16.4A Corrugate Fastening Patterns




Corrugate fixing Patterns

## 3.16.4B Fixing Patterns for 5 Rib Sheeting




5 Rib fastening Patterns at Jan 1 2017

## 3.16.4C Fixing Patterns for 6 Rib Sheeting

These fastening patterns should be used in conjunction with load span graphs.

The load on a purlin and a purlin/rafter connection is determined by the wind load and the area of roof the load is acting upon. Roof fasteners transfer wind uplift-loads to the purlins, which in turn transfer them to the primary structure.

Fastening to every second purlin may be within the roof's load/span range, but will double the load acting on the fastened purlins. All purlins must be fastened to unless alternate purlins are specifically designed to take the additional loads

### 3.16.4D Symmetrical and Assymetrical Fastener Patterns

Symmetrical fastener patterns are more effective.

## 3.16.5 Wind Load Span Graphs

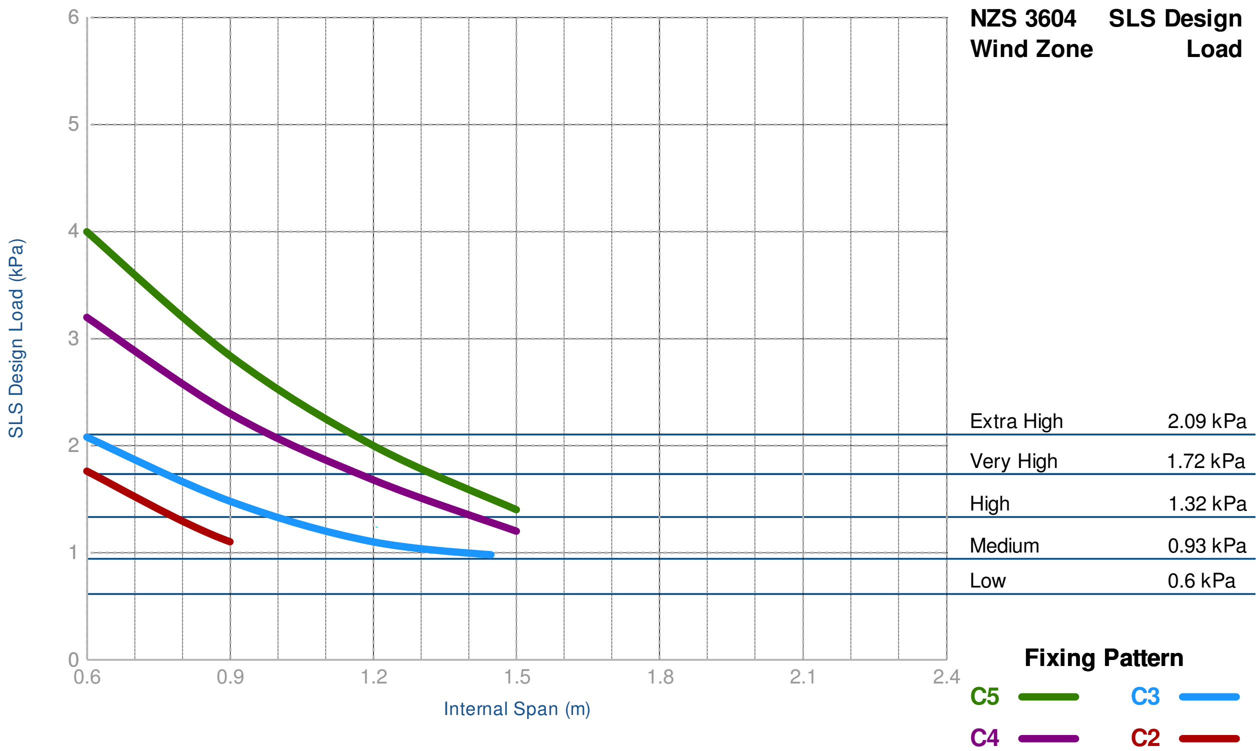
*Wind Load span graphs should be read in conjunction with the constraint of access and the span at which the point load will be the limiting factor.*

*The performance of profiled metal cladding depends on the profile shape, thickness of the metal, the span, and the fastening type and pattern. These values can be greatly enhanced by using load spreading washers or thicker material.*

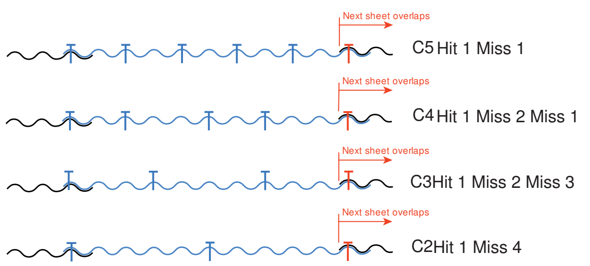
*All the tests from which these graphs have been derived used the 2:3 ratio of end to intermediate span and the graphs shown are for intermediate spans only. End spans must be reduced by two-thirds for these values to be assumed.*

## 3.16.5.1
## Corrugate 0.40 G550 Steel

**Standard Corrugate minimum 16.5 mm high, G550 Steel, 0.40mm BMT**

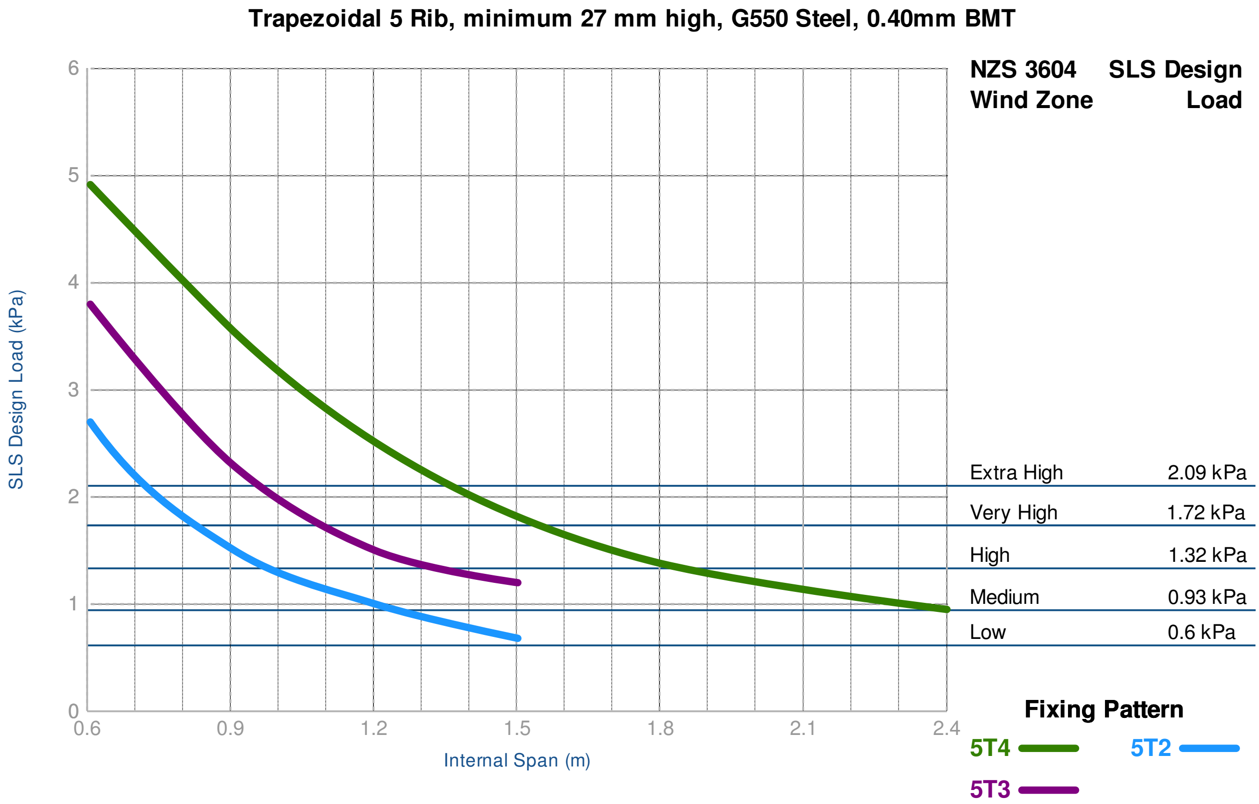



| Recommended Point Load Limit | | Span |
|---|---|---|
| Type A | Unrestricted Access | N/A |
| Type B | Restricted Access | 0.9 m |

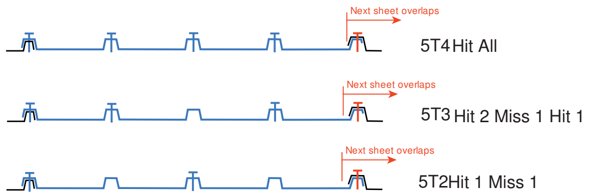



Corrugate fixing Patterns

## 3.16.5.2
## 5 Rib 0.40 G550 Steel



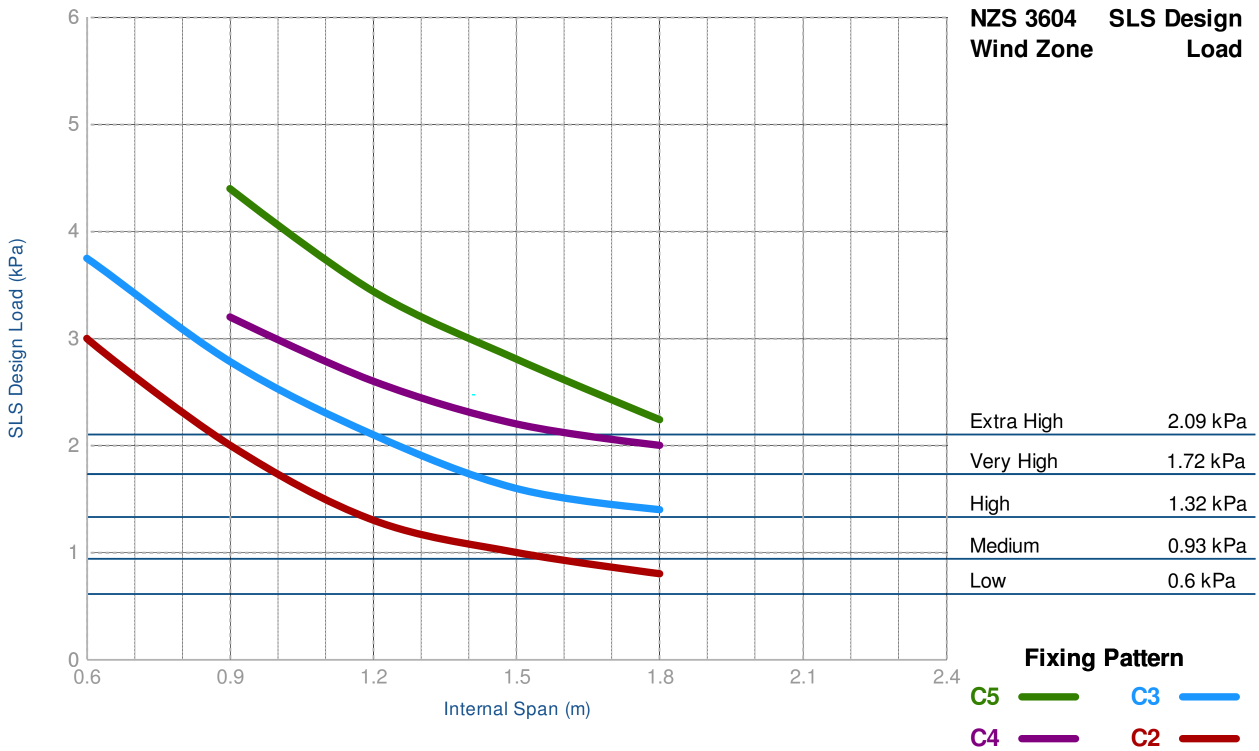

| Recommended Point Load Limit | | Span |
|---|---|---|
| Type A | Unrestricted Access | N/A |
| Type B | Restricted Access | 1.4 m |



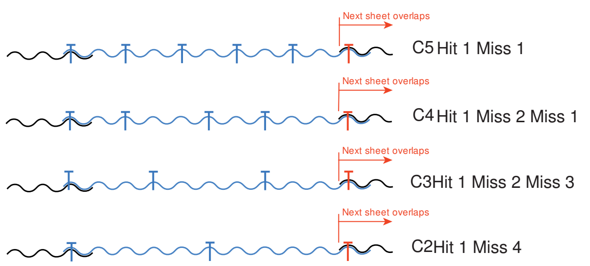

5 Rib fastening Patterns at Jan 1 2017

## 3.16.5.3
## Corrugate 0.55 G550 Steel

**Standard Corrugate minimum 16.5 mm high, G550 Steel, 0.55mm BMT**



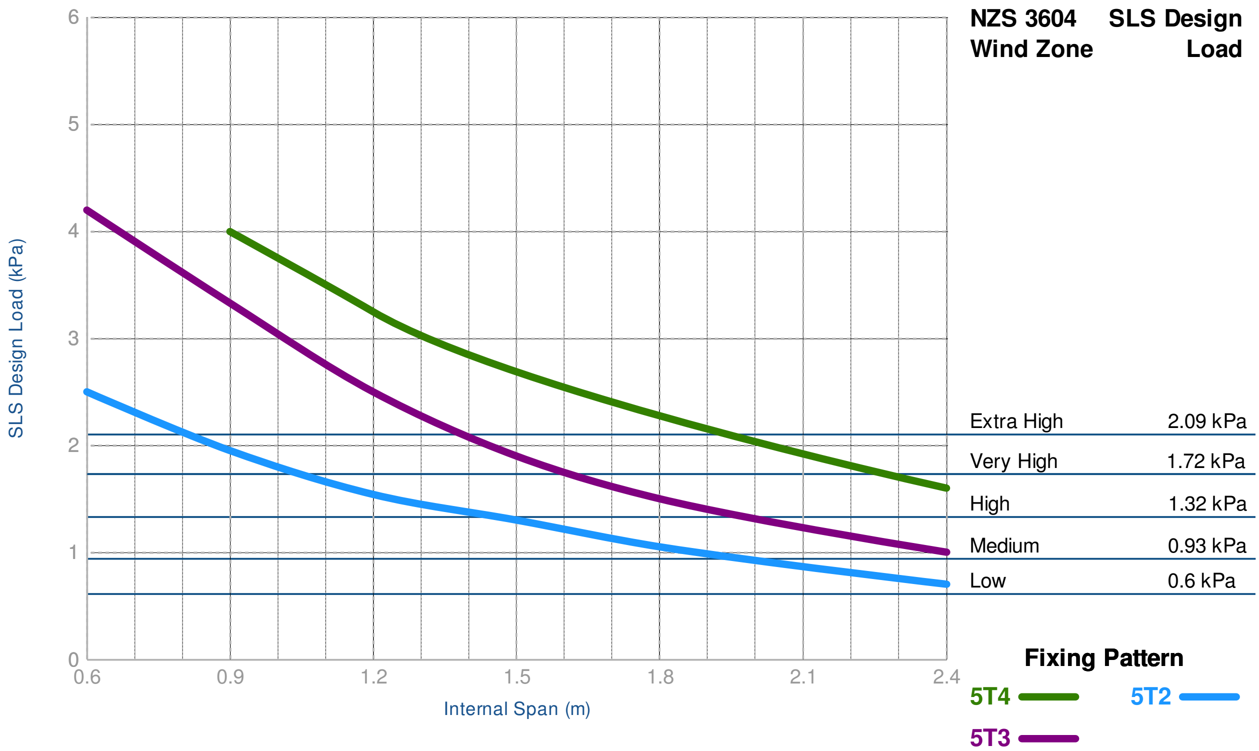

| Recommended Point Load Limit | | Span |
|---|---|---|
| Type A | Unrestricted Access | 1.2 m |
| Type B | Restricted Access | 1.5 m |



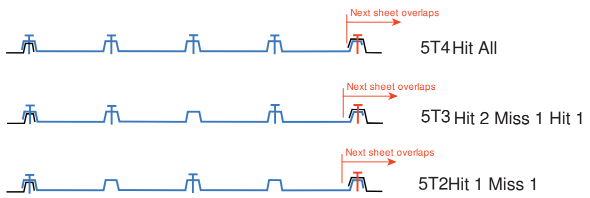
Corrugate fixing Patterns

## 3.16.5.4
## 5 Rib 0.55 G550 Steel

**Trapezoidal 5 Rib, minimum 27 mm high, G550 Steel, 0.55mm BMT**

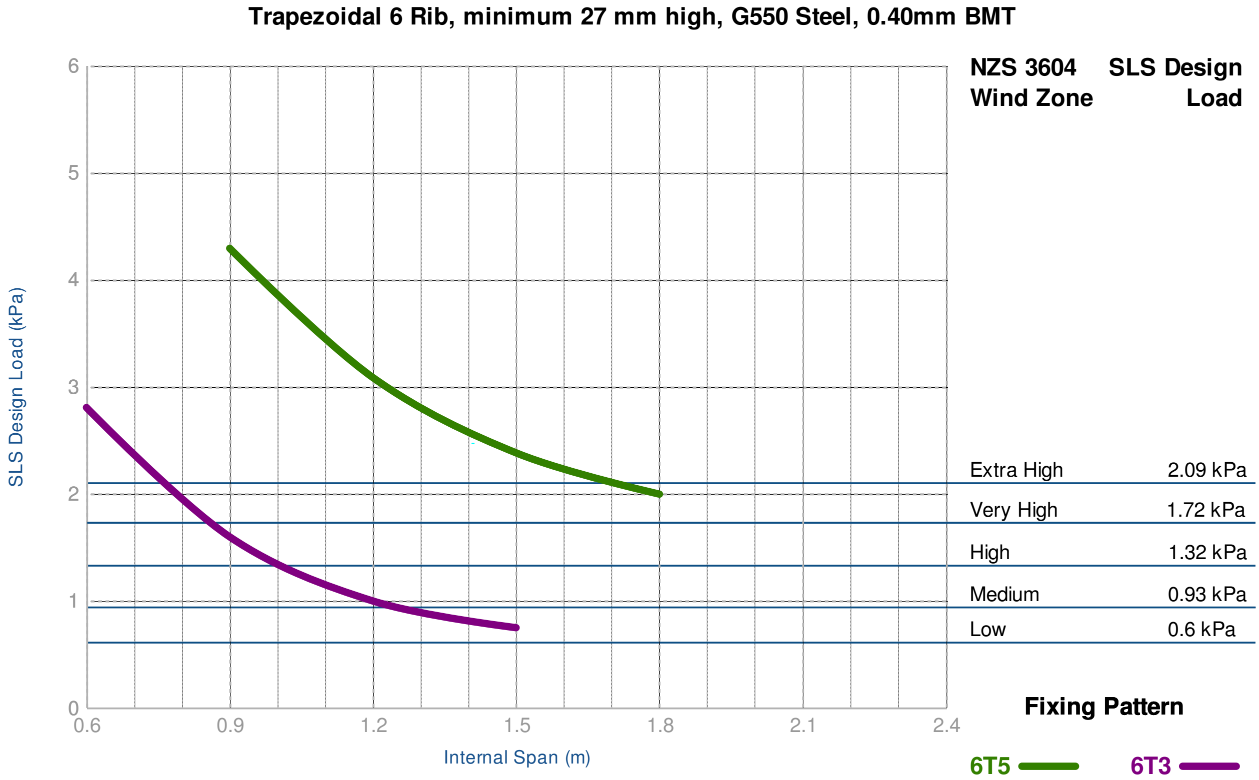



| Recommended Point Load Limit | | Span |
|---|---|---|
| Type A | Unrestricted Access | 1.5 m |
| Type B | Restricted Access | 2.1 m |



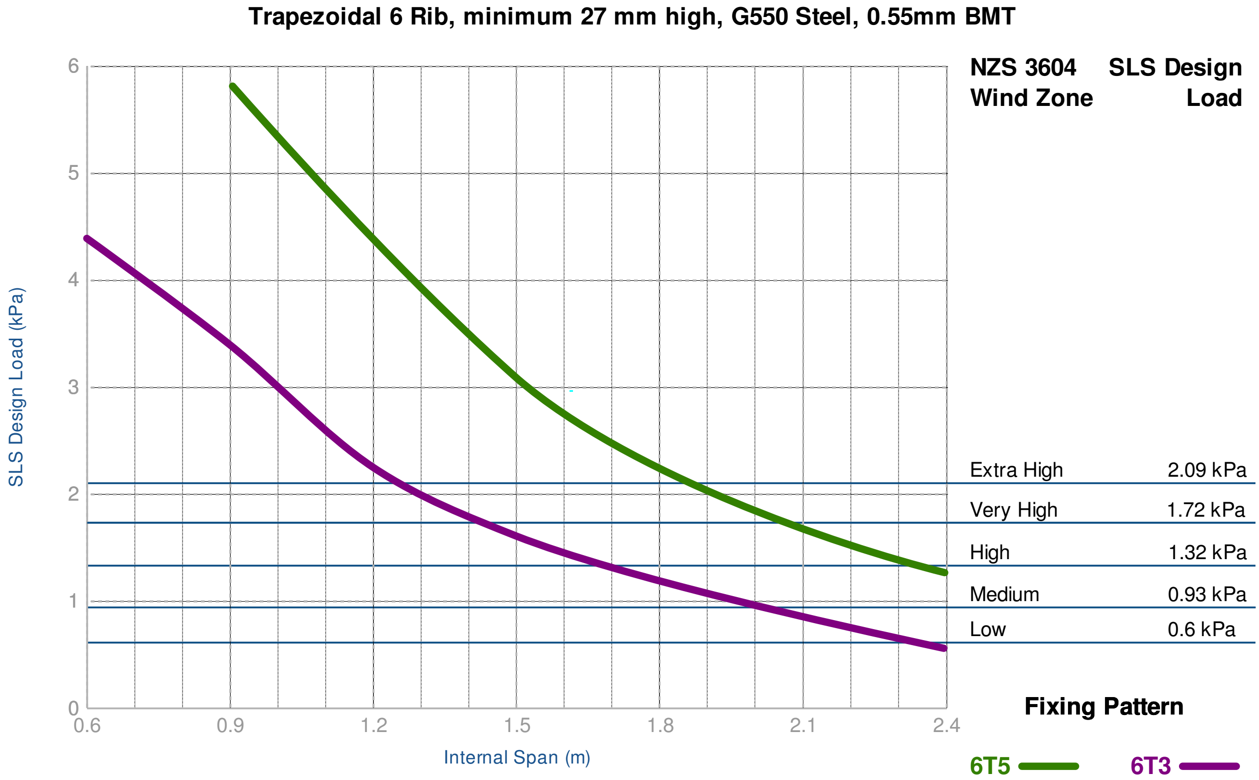

5 Rib fastening Patterns at Jan 1 2017

## 3.16.5.5
## 6 Rib 0.40 G550 Steel




| Recommended Point Load Limit | | Span |
|---|---|---|
| Type A | Unrestricted Access | N/A |
| Type B | Restricted Access | 1.5 m |

## 3.16.5.6
## 6 Rib 0.55 G550 Steel




| Recommended Point Load Limit | | Span |
|---|---|---|
| Type A | Unrestricted Access | 1.5 m |
| Type B | Restricted Access | 2.2 m |

# 4 Durability

*Corrosion (B2-Durabilit*y) covers considerations for continued performance of roof and wall cladding over the building lifecycle.
Key topics include:

- Material performance and coatings.
- Corrosion: evironmetal categories and special climates.
- Material compatibility — both "in contact with" and "runoff onto".
- Maintenance for prevention and remediation of corrosion.

## 4.1 NZBC Clause B2

*Source: New Zealand Building Code, Clause B2 Durability*

### 4.1.1 Objective

**The objective of this provision is to ensure that a building will continue to satisfy the other objectives of this code throughout its life.**

## 4.1.2 Functional Requirements

Building materials, components and construction methods shall be sufficiently durable to ensure that the building, without reconstruction or major renovation, satisfies the other functional requirements of the NZBC throughout the life of the building

## 4.1.3 Performance Requirements

Building elements must, with only normal maintenance, continue to satisfy the performance requirements of the NZBC for the lesser of the specified intended life of the building, if stated, or:

a. The life of the building, being not less than 50 years, if:
- those building elements (including floors, walls, and fixings) provide structural stability to the building; or
- those building elements are difficult to access or replace; or
- failure of those building elements to comply with the building code would go undetected during both normal use and maintenance of the building.

b. 15 years if:
- those building elements (including the building envelope, exposed plumbing in the subfloor space, and in-built chimneys and flues) are moderately difficult to access or replace; or
- failure of those building elements to comply with the building code would go undetected during normal use of the building, but would be easily detected during normal maintenance.

c. 5 years if:
- the building elements (including services, linings, renewable protective coatings, and fixtures) are easy to access and replace; and
- failure of those building elements to comply with the building code would be easily detected during normal use of the building.

Individual building elements which are components of a building system and are difficult to access or replace must either:

- all have the same durability; or
- be installed in a manner that permits the replacement of building elements of lesser durability without removing building elements that have greater durability and are not specifically designed for removal and replacement.

### 4.1.3.1 Compliance

NZBC Clause B2, Durability, requires fifteen years to perforation for claddings easily accessed for replacement. Fifteen years is also required for internal gutters and downpipes, and five years for external gutters.

NZBC B2 requires 50 years' durability for flashings that require the removal of cladding above to be replaced, while table 20 of NZBC E2/AS1 only requires 15 years' durability for such flashings. The COP recommends the higher figure as good trade practice and in many cases, lower life-cycle costing.

Generally, higher durability than the minimum requirements can be achieved by using materials and methods outlined in this COP, with no maintenance of coatings other than washing areas which are not naturally washed by rain. Elements more difficult to replace, or to access for maintenance, should be constructed of more durable material.

*Normal Maintenance* means work recognised as being necessary to achieve the expected durability of a given building element.

According to B2/AS1, normal maintenance may include:

- Washing down surfaces subject to wind-driven salt spray and contaminants.
- Re-coating protective surfaces.
- Replacing sealant seals and gaskets in joints.

Although roof or wall cladding can be easily accessed and therefore easily replaced, the same cannot be assumed for flashings. Flashings might be embedded in plaster or behind other building elements, making them hard to replace without removing cladding or other building features such as windows.

Cladding material may be described as hidden, sheltered or exposed. Some flashings may have sections falling into all these categories, in which case the worst case (sheltered) should prevail in material selection.

**All metal roof and wall cladding and accessories must be designed and installed to comply with the durability requirements of the NZBC. NZBC requirements relate to performance, however, and do not necessarily relate to aesthetics or cost of replacement. Any pre-painted cladding will change colour over time, and partial replacement would be visible. The roof cladding could have deteriorated, although not perforated, within 15 years and still comply with the NZBC, but customer expectations may not be met.**

Good design, correct selection of materials, and good installation and maintenance practices are required to achieve optimum product lifespan.

## 4.2 Metal Corrosion

Corrosion is the process by which something erodes because of a chemical reaction.

Metal corrosion is a reaction of metal with its environment that causes measurable alteration and is part of metal's inherent tendency to revert to an original, more stable form. The red rusting of iron and steel is a visible example of corrosion and other examples include the weathering of copper, and oxidation of aluminium and zinc.

Corrosion can only happen in the presence of an electrolyte, e.g., water. The occurrence of salt (or other contaminants) in the water increases the conductivity of the electrolyte and therefore greatly increases the reaction rate.

Corrosion can also be the result of direct contact with another metal or substance, or the result of run-off from incompatible surfaces or fall-out of corrosive particles. Time of wetness, presence or lack of oxygen, and atmospheric contaminants greatly affect the rate of corrosion.

Differences in electrical potential on the surface of corroding metal create microscopic cells comprising cathodes and anodes. In the case of iron, the positively charged electrons in the anode react with the negatively charged hydroxyl ions in the electrolyte to form iron oxide on the anode. Similar reactions occur with other metals. Polarisation changes on the surface cause anodic areas to become cathodic and vice versa, so that over time the rate of corrosion is relatively uniform over the surface.

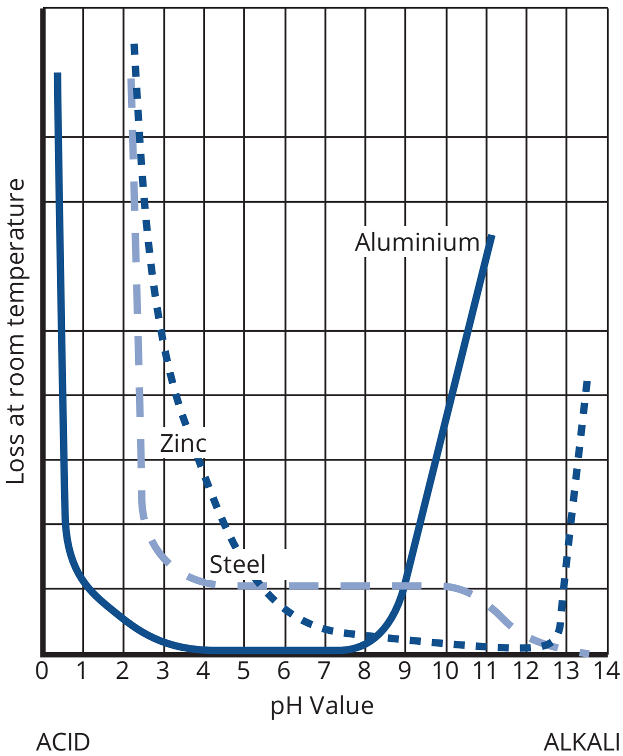
The build-up of debris on a cladding surface will promote corrosion. The salts in the debris react with the cladding each time they are wetted, and the deposits themselves impede surface-drying, increasing the time of wetness.

## 4.3 Metal Performance

To understand metal performance in any specific environment, the unique properties of each metal should be considered in conjunction with other metals it is used with.

All metals react differently to the atmosphere and to any contaminants that come into contact with their surface by rain, wind or condensation. The indicator of acidity or alkalinity is pH, measured from 0 – 14; acidity/alkalinity is an important corrosion factor. pH 7 is neutral, below 7 is more acidic, above 7 is more alkaline.

### 4.3A Metal Performance in Acid/Alkaline Environments




As can be seen from the graph above, zinc performs better in alkaline environments, and aluminium performs better in acidic environments.

Aluminium-zinc coatings should be avoided in buildings such as closed animal shelters or fertiliser storage sheds, where alkalinity may be high.

## 4.4 Sacrificial and Barrier Protection

**The zinc and aluminium families of metallic coatings protect the steel base from corrosion in two different ways:**

- **Zinc predominant coatings protect the substrate primarily by offering sacrificial protection.**
- **Aluminium predominant coatings primarily offer barrier protection.**

### 4.4.1 Sacrificial Protection

**Zinc is more electrically active than steel. By coating steel with zinc, or a zinc-rich product, the zinc becomes the anode for the steel. The steel then becomes the cathode and does not react with the electrolyte. The process is known as cathodic protection.**

**This protective effect occurs even when there is a small area of steel exposed directly to the electrolyte, such as a cut sheet edge, drill hole or scratch.**

**While the zinc reacts in preference to the steel, it does so at a slower rate. In normal environmental conditions, the zinc-oxide layer that initially forms on the surface of the zinc combines with carbon dioxide in the atmosphere to form zinc carbonate. That creates a sealed layer with excellent adhesion, and as zinc carbonate has very low solubility, reaction with the electrolyte slows even more.**

### 4.4.2 Barrier Protection

Barrier protection works primarily by providing a physical barrier between the atmosphere and the steel substrate.

The surface of aluminium-dominant coatings is initially very active, but it quickly forms an inert aluminium-oxide film when exposed to normal atmospheric conditions. Aluminium dominant coatings on steel mainly provide barrier protection as the aluminium, having formed an oxide surface, ceases to offer substantial sacrificial protection.

The exposed edges of barrier protected cladding should not be in contact with corrosive surfaces. See 4.10.3 Compatibility Table

# 4.5 The Environment

## 4.5.1 Atmosphere

**The durability performance of metal roof and wall cladding depends on the macro- and microclimates, airborne contaminants, and the material itself.**

**The macroclimate is the general environmental category where the building is situated.**

*The microclimate relates to the exact location of the building and the design or position on the roof or wall. Microclimate influences include geothermal fumaroles, rain sheltering, topography and ground roughness, prolonged wetness, and exclusion of oxygen. Internal microclimates can also occur as result of the particular use of the building.*

*Contaminants and pollutants are corrosive influences which can affect the cladding. These can include fertiliser, soil, leaf fall-out, exhaust fumes, industrial fumes, bird droppings and the build-up of debris. Influences such as chlorides near the sea, geothermal hydrogen sulphide ($H_2S$) or man-made gases such as sulphur dioxide ($SO_2$) accelerate the corrosion rate by increasing the conductivity of the electrolyte and changing its pH value.*

*Rain provides the moisture that acts as the electrolyte in corrosion cells. Rain varies in pH because it picks up various contaminants from the pollutants in the atmosphere. Acid rain can happen in geothermal areas due to the presence of hydrogen sulphide in the atmosphere.*

*At 0°C metal corrosion is minimal, because colder temperatures slow the reaction. The corrosion rate of some metals doubles with every 10°C rise in temperature given the same time of wetness and environmental conditions. However, in dry, warm environments the time of wetness is decreased by faster drying times, which has the opposite effect.*

**Designers should be aware of macro- and microclimates and the degree of contamination. They should design their building and select materials considering a combination of all these factors.**

## 4.5.2 Sea Spray

The major contributor to metal corrosion in New Zealand is sea spray. Sea spray contains a mixture of salts consisting of 2.5 to 4% sodium chloride and small quantities of magnesium, calcium and potassium chloride. These salts make water far more electrically conductive.

Sea spray, evaporation, and infrequent rain increase salt concentrations on exterior surfaces, particularly when it accumulates in unwashed areas.

## 4.5.2A Airbone Salt from Sea Spray.

*Onshore winds, big swells, wide generation zone and rugged coastline make ideal conditions for the production of salt aerosol.*

The distance airborne salt is carried inland varies significantly with local wind patterns. Salt deposits have been measured as far inland as Lake Taupo in the North Island. Geographic or man-made obstructions, such as trees or buildings, slow air velocity and allow the air to discharge some of its salt burden, which can make the environment less aggressive. Conversely, where there are few impediments to the free flow of air, severe marine influence can extend well inland.

In high humidity levels, or when wetted by condensation, marine salts absorb water and form a chloride solution. Therefore, the effect of salt spray is greatest in unwashed areas, where salts can accumulate over time.

Where the ends of roof cladding are exposed to contaminants such as sea salt or industrial pollutants, it is good practice to provide an over flashing which discharges into the gutter or spouting. (See 8.4.4.4A Over Flashing.)

- It gives a measure of protection to the underside of the roof cladding and the underlay.
- It provides support for the roofing underlay which is subject to damage from wind and UV.
- When using PVC spouting, there is a gap between the spouting and the fascia caused by the thickness of the brackets. In coastal locations where the ends of roof cladding are exposed, this unwashed area becomes susceptible to corrosion. A gutter apron can minimise this risk.
- If there is no spouting or it has a low front.
- In severe environments, wind can drive contaminants up the ribs of exposed ends of roof cladding. Metal scriber flashings or filler blocks can be used to prevent or inhibit ventilation.

The over flashing should extend 50 mm into the gutter, and the underlay finishes on the down-slope of the flashing. If there is no over-flashing to the gutter, the underlay should be extended into the gutter by a minimum of 20 mm.

In some cases, the over flashing becomes a sacrificial flashing which can extend the life of the cladding. In such circumstances, the COP recommends making the flashing from aluminium.

## 4.6 Environmental Categories

Suppliers of pre-painted metal offer alternative products for different environments, using different metallic coatings, paint systems, paint thickness and metals. The designer or the roof cladding contractor should carefully assess and evaluate these options to comply with the NZBC.

The boundaries of different corrosion zones are difficult to define because many factors determine the corrosivity of a particular location. The designer should choose the appropriate materials for the location, which meet the minimum durability requirements of the NZBC and satisfy customer expectations.

### 4.6.1 Assessment of Marine Environments

Wind is responsible for the salinity present in marine atmospheres. The wind picks up particles of salt from breaking waves and can carry them inland. The quantity of salt aerosol entrained by the wind is affected by many factors, such as wind strength, wave height, the width of the generation zone, and the contours of the seabed and coastline. These factors along with the persistence of the wind from a given quarter determine the corrosivity of a shoreline.

While salt deposits are measurably present in inland areas such as Taupo, the main effect of marine atmospheres reaches just a few hundred metres from the shore.  Particles of salt in the air deposit on adjacent surfaces through gravity and contact; the rate at which deposits settle is affected by the roughness of the ground that the salt-laden air passes over. Obstacles such as trees slow the wind down, increasing the rate of gravitational deposit, and bringing the salt aerosol in more contact with surfaces on which they can deposit.

On the other hand, open flat land and natural “wind tunnels” can allow quite high concentrations of salt to travel several hundred metres inland.

A site’s location, relative to the sea or marine inlets, is a common method used to assess the corrosivity of a location. The distance from salt water for a given Zone varies with the location, depending on the prevailing winds and roughness of water in those areas, as well as the evenness of the terrain it passes over.

Where environmental Zones overlap, a site-specific evaluation may help define the category into which it best fits.  Visual evidence of corrosion on adjacent metal surfaces may be present, ground roughness can be assessed, industrial influences can be evaluated and data about the persistence of onshore winds can be obtained from NIWA.

More local factors that affect the corrosivity of a specific location include:

- Overhanging shade increases the time of wetness of a structure and corrosion rate.
- High levels of water roughness such as caused by strong tidal flow against the wind direction, as is often experienced in areas such as Cook Strait, increases salt spray.
- Surfaces not receiving regular and effective rain washing or sufficient manual washing may experience corrosion rates two to three times that of cleaned surfaces.

There are many ways of more accurately determining the actual corrosivity of a given location. The most commonly accepted method as outlined in ISO 9223 is measuring first-year corrosion rate of different metals: mild steel (MS), zinc, aluminium and copper. The COP uses the first-year corrosion rate of mild steel as the most relevant and reliable indicator of a location's corrosivity.

The names given by different Standards for given corrosion zones vary. The Corrosion Zones in the Code of Practice are similar to those published in NZS 3604:2011 except that:

- the COP makes a distinction between Harbours, West Coast, and East Coast shorelines, and
- NZS 3604 Zone D (High) is further broken down into E (Very High) and F (Extreme Marine) because, in NZS 3604 Zone D, the first-year mild steel corrosion rate can vary from 200 g/m$^2$ to 1000 g/m$^2$.

## 4.6.1A Corrosion Zone Categorisation and First year Mild Steel Corrosion Rate (g/m²)

| NZS3604 | Code of Practice | Description | MS Corrosion Rate (g/m²) |
|---|---|---|---|
| B | A (Mild) | Far inland, with no industrial pollution or thermal activity, or dry internal. This condition is not commonly found externally in New Zealand. | 1 – 10 |
| | B (Moderate Inland) | Most dry rural areas in New Zealand, 50 km from the coast, are in this category. It can extend closer to the coastline of sheltered water in low rainfall areas. | 10 – 80 |
| C | C (Moderate Marine) | This category covers area of low marine influence. It can extend from 50 km inland to within 1 – 1.5 km of west coast beaches, or be in the immediate vicinity of calm estuaries. | 80 – 200 |
| D | D (Severe Marine) | In this category, marine influences are frequently apparent. Its proximity to the coast is determined by the roughness of the water, prevailing winds, ground roughness and sheltering. | 200 – 400 |
| | E (Very Severe Marine) | In this category, the structure is normally exposed and marine influences are almost constantly apparent. | 400 – 650 |
| | F (Extreme Marine) | This category is rare in a building site. It would be an exposed location very close to breaking surf. | 650 – 1 000 |

## 4.6.2 Environmental Guides

The following tables provide guidance for specific regions and environments. See 4.6.1A Corrosion Zone Categorisation and First year Mild Steel Corrosion Rate (g/m²) for descriptions of specific categories.

## 4.6.2A West Coast and South Coast; both Islands

| Zone | Distance from the Shoreline. |
|---|---|
| B<br>Moderate Inland | 55 km |
| C<br>Moderate Marine | 1000 m – 60 km |
| D<br>Severe Marine | 200 m – 1 200 m |
| E<br>Very Severe Marine | 100 m – 300 m |
| F<br>Extreme Marine | 150 m |

## 4.6.2B East Coast (Including West facing shores of large harbours)

| Zone | Distance from the Shoreline. |
|---|---|
| B<br>Moderate Inland | 50 km |
| C<br>Moderate Marine | 500 m – 55 km |
| D<br>Severe Marine | 100 m – 600 m |
| E<br>Very Severe Marine | 50 m – 200 m |
| F<br>Extreme Marine | 75 m |

## 4.6.2C Harbours

| Zone | Distance from the Shoreline |
|---|---|
| B<br>Moderate Inland | 45 km |
| C<br>Moderate Marine | 200 m – 50 km |
| D<br>Severe Marine | 500 m |
| E<br>Very Severe Marine | 50 m |

## 4.6.2D Estuaries (Calm Inlets)

| Zone | Distance from the Shoreline. |
|---|---|
| B<br>Moderate Inland | 45 km |
| C<br>Moderate Marine | 50 km |
| D<br>Severe Marine | 50 m |

## 4.6.3 Material Selection

Note: this is the minimal requirement to achieve compliance with NZBC Clause B2-Durabilty. Meeting the minimum requirements of NZBC clause B2 Durability does not necessarily represent optimal product selection. In a transition zone, it may be more cost effective over the life cycle of the building, and for meeting customer expectations, to choose a more durable option.

## 4.6.3A Material Selection : Exposed Roofs and flashing

### Durability Required : 15 years

| Marine Zone | Exposed Fastener Class (minimum) | Acceptable Materials |
|---|---|---|
| ***As defined by AS/NZS 2728. | | |
| **B: Moderate Inland** | C4 | Aluminium<br>Pre-painted aluminium<br>Pre-painted steel Type 6***<br>Pre-painted steel Type 4***<br>AZ 150 coated steel<br>Galvanised steel Z 450 |
| **C: Moderate Marine** | C4 | Aluminium<br>Pre-painted aluminium<br>Pre-painted steel Type 6***<br>Pre-painted steel Type 4***<br>AZ 150 coated steel<br>Galvanised steel Z 450 |
| **D: Severe Marine** | C4 | Aluminium<br>Pre-painted aluminium<br>Pre-painted steel Type 6***<br>Pre-painted steel Type 4*** |
| **E: Very Severe Marine** | C5 | Aluminium<br>Pre-painted aluminium<br>Pre-painted steel Type 6*** |
| **F: Extreme Marine** | C6 | Aluminium<br>Pre-painted aluminium |

*Materials accepted by NZMRM as complying with coating types include:*

- *Painted steel Type 4:*
  *Colorsteel® Endura®, Colorcote® ZinaCore™*
- *Painted steel Type 6:*
  *Colorsteel® Maxx®, Colorcote® MagnaFlow™, Colorcote® MagnaFlow X™*

## 4.6.3B Material Selection : Walls*, fascias and sheltered roofs and flashings

### Durability Required : 15 years

| Marine Zone | Exposed Fastener Class (minimum) | Acceptable Materials |
|---|---|---|
| *The practicality of carrying out regular maintenance, and difficulty of replacement, should also be considered when considering wall cladding material options. | | |
| ***As defined by AS/NZS 2728. | | |
| **B: Moderate Inland** | C4 | Aluminium<br>Pre-painted aluminium<br>Pre-painted steel Type 6***<br>Pre-painted steel Type 4***<br>AZ 150 coated steel<br>Galvanised steel Z 450 |
| **C: Moderate Marine** | C4 | Aluminium<br>Pre-painted aluminium<br>Pre-painted steel Type 6***<br>Pre-painted steel Type 4***<br>AZ 150 coated steel |
| **D: Severe Marine** | C4 | Aluminium<br>Pre-painted aluminium<br>Pre-painted steel Type 6*** |
| **E: Very Severe Marine** | C5 | Aluminium<br>Pre-painted aluminium<br>Pre-painted steel Type 6*** |
| **F: Extreme Marine** | C6 | Aluminium<br>Pre-painted aluminium |

*Materials accepted by NZMRM as complying with coating types include:*

- *Painted steel Type 4:*
  *Colorsteel® Endura®, Colorcote® ZinaCore™*
- *Painted steel Type 6:*
  *Colorsteel® Maxx®, Colorcote® MagnaFlow™, Colorcote® MagnaFlow X™*

## 4.6.3C Material Selection : Flashings Behind Cladding

### Durability Required : 50 years

| Marine Zone | Acceptable Materials |
|---|---|
| **Stainless steel must not be in wet contact with metallic coated steel, plain or painted. | |
| ***As defined by AS/NZS 2728. | |
| **B: Moderate Inland** | Stainless Steel** |
| | Aluminium |
| | Pre-painted aluminium |
| | Pre-painted steel Type 6*** |
| | Pre-painted steel Type 4*** |
| | AZ 150 coated steel |
| | Galvanised steel Z 450 |
| **C: Moderate Marine** | Stainless steel** |
| | Aluminium |
| | Pre-painted aluminium |
| | Pre-painted steel Type 6*** |
| **D: Severe Marine** | Stainless steel** |
| | Aluminium |
| | Pre-painted aluminium |
| **E: Very Severe Marine** | Stainless steel** |
| | Aluminium |
| | Pre-painted aluminium |
| **F: Extreme Marine** | Stainless steel** |
| | Aluminium |
| | Pre-painted aluminium |

*Materials accepted by NZMRM as complying with coating types include:*

- *Painted steel Type 4:*
  *Colorsteel® Endura®, Colorcote® ZinaCore™*
- *Painted steel Type 6:*
  *Colorsteel® Maxx®, Colorcote® MagnaFlow™, Colorcote® MagnaFlow X™*

## 4.7 Special Climates

In areas where humidity or local conditions create an increased likelihood of corrosion, special consideration should be given to the specification and use of metal roof and wall cladding and accessories.

### 4.7.1 West Coast, South Island, South Coast, North Island

The West Coast is characterised by high rainfall and a very severe coastal environment between the sea and the Southern Alps; many households have coal burning fires that produce sulphur dioxide that is detrimental to metals.The combination of these factors means that either a shorter performance life should be accepted or the use of more durable metals and coatings considered.

The North Island's south coast not only has strong onshore prevailing winds, but strong current flows increase wave action and the amount of salt-laden air, creating a particularly harsh marine environment.

### 4.7.2 Geothermal

Buildings within 50 m of a geothermal fumarole are considered to have a geothermal microclimate, which causes increased corrosion due to higher humidity levels combined with hydrogen sulphide.

Highly active geothermal areas, such as much of Rotorua, are considered geothermal, even in the absence of a local fumarole.

### 4.7.3 Internal Environments

Corrosive internal environments with high humidity, causing condensation, and pollutants generated within the building can also affect neighbouring buildings. These include:

- covered swimming pools;
- fertiliser works;
- meat works;
- animal sheds or shelters;
- pulp and paper manufacturing; and
- vehicle exhaust fumes.

### 4.7.4 Fossil Fuel Residue

Sulphur dioxide develops when burning fossil fuels. After oxidation and reaction with water it forms sulphuric acid ($H_2SO_4$) that can contribute considerably to the atmospheric corrosion of zinc and steel.

Burning resinous woods, CCA-treated timber, low-grade coal or oils with a high sulphur content can increase the fall-out deposit or condensate from flue gas.

Exhaust fans can cause similar problems when corrosive gases are not filtered at their source.

## 4.8 Biological Corrosion

Organic acids can be produced by colonies of micro-organisms. Within these colonies, they create anodic and cathodic zones which forms electrical cells that can react with a metal surface to cause corrosion.

### 4.8.1 Lichen

Warm temperatures, dust, and rainfall can create an environment for lichens to flourish. Over time the root structures of lichen may infiltrate a painted surface and cause permanent damage.

Lichen growths retain moisture and, therefore, increase the time of wetness. They are fed by nutrients in the atmosphere and tend to occur more commonly in moist and unpolluted environments. Where lichen growth is present, it should be removed. See 16 Maintenance .

Physical removal is difficult to achieve completely, and recolonisation is usually rapid. Chemical treatment is recommended. New Zealand Steel publishes a formula for batching a 2% sodium Hypochlorite solution to be used for this.

#### 4.8.1C

4.8.1D

4.8.1C

4.8.1D

## 4.8.2 Gutter Leaf Guard

Leaf guards are widely marketed as a way to prevent the build-up of vegetable matter in spouting. They may achieve this objective, but they often result in a build-up of a plant material poultice on the eaves line of the roof.

That can cause premature corrosion of the roof by chemical reaction, greatly increased time of wetness, and prevention of adequate ventilation of the underside of the cladding.

The COP recommends against the installation of such products. Alternative solutions include fitting a durable spouting material such as copper, installing rain heads with a leaf trap, or installing a proprietary leaf-proof spouting system.

## 4.8.2A Leaf Diverter

## 4.8.2B Proprietary Leaf Proof Spouting System

## 4.8.2C Proprietary Leaf Proof Spouting End Cap

## 4.9 Paint Durability

New Zealand has a harsh level of ultraviolet light. Paint formulations that are successful overseas have sometimes been found lacking colour fastness in the Australasian environment. Proprietary pre-painted cladding products should give durability protection and keep its appearance for at least 15 years, and at the end of that period still have the anti-corrosive primers intact and present a good substrate for over-painting.

The performance of all paint coatings, however, can be affected by avoidable outside influences.

### 4.9.1 Touch-up Paint

Colour match paint is sold in pre-colour matching accessories, such as soft edging or brackets, to match the pre-painted cladding. It should only be pre-applied before installation and should not be used to repair minor scratches and blemishes. These paints may closely match the pre-painted surface initially, but being an air drying acrylic, it is likely to weather differently to the pre-applied coating and cause unsightly blotches.

#### 4.9.1A Touch-up Paint Weathering

### 4.9.2 Sunscreen Lotions

Sun screen lotions containing semi conducting metal oxides, such as titanium dioxide and zinc oxide, will cause discoloration of painted surfaces over time. There is no cure for such damage so contact of such chemicals with pre-painted cladding must be avoided.

### 4.9.2A Sunscreen Lotion Marks

## 4.9.3 Graffiti Removal

Most Graffiti removal processes involve the use of strong solvents, abrasion, or extreme temperatures. It is generally difficult to remove graffiti without compromising an existing organic finish; the normal remedy is to overpaint as soon as possible. On a weathered pre-painted finish this can generally be achieved by washing and rinsing the surface to remove dirt and other contaminants, then applying two coats of acrylic paint.

It should be noted that such overpaint cannot over time, be expected to match the appearance of existing pre-applied finishes.

## 4.10 Compatibility

Materials comprising the building envelope should not be considered in isolation, as their performance can be affected by contact with or run-off from other materials.

This reaction is caused by either their relative places in the electro-chemical series or by the mineral composition of their surface moisture.

## 4.10.1 Disimilar Metals

A component which may appear suitable may prove unsatisfactory in service because it is incompatible with another material or substance in contact with it.

This incompatibility can occur when the metals are in electrolytic contact or when water from one metallic surface discharges onto another. When a noble metal dissolves in water and flows over a less noble one, the more noble metal deposits on the less noble metal and create corrosion conditions.

### 4.10.1A Galvanic Series

**Galvanic Series**

| | |
|---|---|
| Magnesium | Active (Anode) |
| Zinc | ▲ |
| Galvanised Steel | |
| Aluminium | |
| Mild Steel | |
| Cast Iron | |
| Lead | |
| Brass | |
| Copper | |
| Bronze | |
| Monel | |
| Nickel (passive) | |
| Stainless Steel 304 (passive) | |
| Stainless Steel 316 (passive) | |
| Silver | |
| Titanium | |
| Gold | |
| Graphite | |
| Platinum | Noble (Cathode) |

The similarity of metals is indicated by their relative position in the galvanic series. The more dissimilar the metals, the greater the corrosion potential in a galvanic circuit

Generally, run-off from metals higher on the table to those lower will not cause corrosion, but run-off in the other direction may do so.

Metals such as aluminium, stainless steel, and Zincalume® form an inert surface that does not produce soluble salts and run-off from them will not result in dissimilar metal corrosion. However, because these surfaces are inert, potential for run-off to create inert catchment corrosion on unpainted zinc or galvanised steel must be considered.

## 4.10.1B Lead in Contact with AZ

*Caption lead in contact with coated or uncoated AZ will cause premature corrosion.*

## 4.10.1C Cladding in Contact with Stainless Steel Rivet

*Stainless rivets will cause corrosion to Z AZ and ZA coated products.*

## 4.10.2 The Electrochemical or Galvanic Series

The electrochemical tables or galvanic series scales, often quoted in technical literature as a measure of corrosion, show the electro-potential between pure metals, not between their oxides, carbonates or chlorides.

Although theoretically correct, these tables can give a misleading indication of the performance of different materials in contact.

This series only applies to pure metal. Under certain conditions, some metals react with the environment or chemicals to form a passive surface, which renders them less active, so that any ranking can be misleading. "Passivity" becomes an important phenomenon in controlling corrosion rates.

However, the Electrochemical series table is still a useful indicator of electrode potential. The further apart two metals are in the electrochemical series, the greater the potential difference between them.

Metals termed anodic, active, negative, or less noble corrode in preference to metals that are deemed more cathodic, noble, positive or less active. The less noble metal becomes the anode and is subject to corrosion. The greater the potential difference, the more corrosion there will be of the less noble metal; i.e., on the anode.

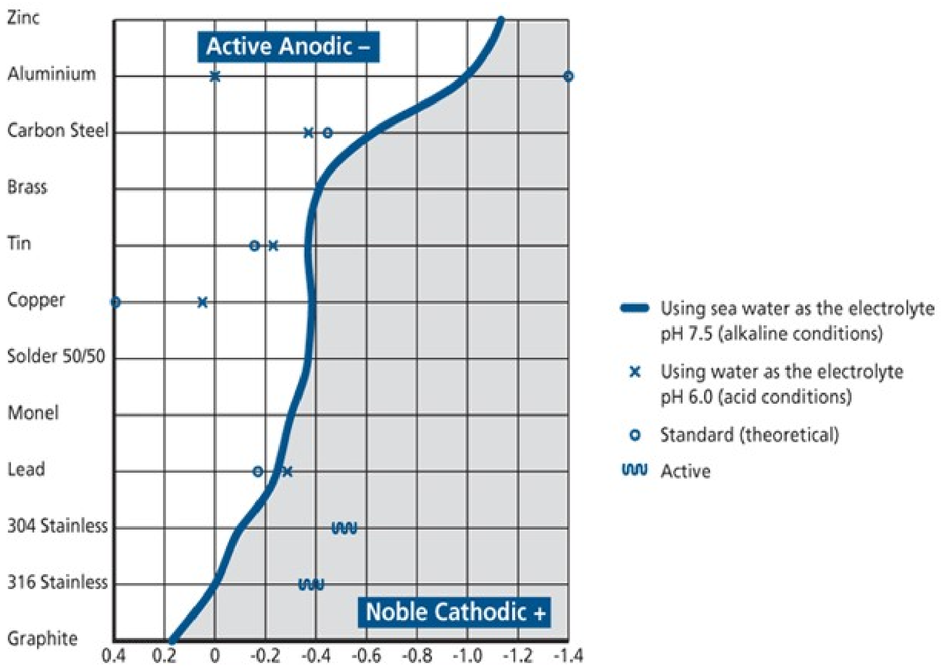
The difference in nobility is why zinc can protect a steel substrate.

Different electrolytes can lead to different rankings, and metal alloys may display more than one potential than that which applies to their "active" state.

The exposed surface ratio of anode and cathode determines the rate of dissimilar metal corrosion. For instance, if a fastener which has a small surface compared to the cladding becomes the anode, its current density will be high, and the fastener will corrode quickly; e.g., an aluminium rivet in a copper sheet. When the opposite is the case, the effect is not so great.

The 4.10.2A Electrochemical table shows zinc is more active than steel. Contact between steel and zinc, in the presence of moisture, will cause the zinc to corrode or sacrifice itself, to protect the steel.

## 4.10.2A Electrochemical table




Galvanic Series in Seawater pH 7.5
Volts vs Saturated Calomel Reference Electrode

## 4.10.3 Compatibility Table

The compatibility table should be regarded as indicative only, due to the many permutations of the environment, the amount of moisture present and the relative size of the components.

The indicator for “use with caution in moderate environments” should be interpreted as a warning that it could be unsuitable when there is a risk of continued moisture or other contaminants.

Timber is generally acidic, although some timbers—such as cedar—are more acidic than others. The interaction between preservative treated timber and metal depends on the moisture content of the timber, the time of wetness and the type of treatment. The corrosion rates of metal in contact with wet CCA-treated timber and with untreated radiata are similar.

## 4.10.3A Butyl Rubber in Wet Contact with Cladding

*Butyl rubber in wet contact with coated aluminium and steel has been found to accelerate corrosion.*

Where the use of dissimilar metals is unavoidable, a non-absorbent inert material can be used as an electrolytic separator. Long-term corrosion resistance depends on the separation remaining effective.

Examples of separation materials are inert plastic tapes, polythene or silicone sealant, and in the case of fasteners an EPDM sealing washer.

When gutters and spouting are made from metals incompatible with roof cladding, there can be contamination from splashing or immersion of the roof sheet ends into the poorly drained gutter. Special provisions—such as painting the inside of a copper spouting, or an apron flashing—should be made when using copper or lead gutters and spouting with coated steel roof cladding. See 14.3 Fasteners. The top of copper spouting should not touch coated steel cladding, tiles or flashings.

Neither AZ coated steel nor aluminium should be used as a flashing embedded in concrete or masonry.

### 4.10.3B Interactive Material Compatibility Tool

The Code of Practice Online provides an interactive tool to interpretation of the information in the 4.10.3C Material Compatibility Table Table, by simply selecting the two materials in use to view compatibility. This tool is only available online at www.metalroofing.org.nz_cop_durability_compatibility#compatibility-table...<_a><_p>

# 4.11 Other Causes of Corrosion

## 4.11.1 Unwashed Areas

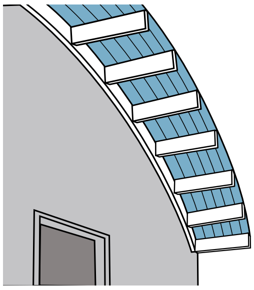
Areas on a building that seldom receive rain-washing gather salt, dust and other contaminants. When condensation, dew or humidity moistens these particles, they react with metal cladding. The reaction is often noticeable as a white zinc corrosion effect, which will precede more serious corrosion.

An unwashed or sheltered area is any surface that is above or inside a line drawn at 45° to any weathertight overhang. Such areas require special consideration, particularly in severe environments.

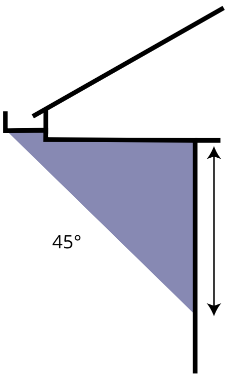
Unwashed areas include: unlined soffits, roof overhangs, canopies, sheltered walls, and the upper part of garage doors.

Wall claddings receive less effective rain washing than roofs, and may be harder to maintain or replace, so materials for wall cladding should be selected accordingly.

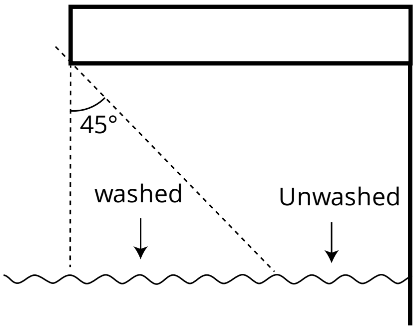
### 4.11.1A Unwashed Soffits




### 4.11.1B Unwashed Wall



## 4.11.1C Unwashed Area




## 4.11.1D Unwashed Wall Below Soffit

## 4.11.2
## Poultice Corrosion

Poultice corrosion or 'under deposit corrosion' is caused when a collection of fine dust — e.g., from earthworks and quarries, or sawdust and shavings from timber processing plants — collects in crevices behind laps or flashings.

These collections increase the time of wetness and retain contaminants.

Bird droppings can contain highly corrosive and adhesive materials that will affect metallic cladding. Birds can also deposit other injurious material, e'g', fish frames and chicken bones.

## 4.11.3 Solar Collectors and other roof mounted structures

Solar energy collectors consisting of solar water heaters or photovoltaic (PV) panels may be attached directly to the surface of profiled metal roof cladding or mounted on a frame above the roof plane.

For direct fastened applications, a complete seal between the PV cells and the cladding is essential to prevent water ingress resulting in wet storage corrosion.

Solar frames installed above the roof surface must have a sufficient gap underneath to allow manual washing of the roof surface. The minimum gap is 100 mm, but greater clearance may be required for more extensive installations.

The unit must be connected to the roof at the rib adjacent to a purlin line, have a waterproof seal, and be made of materials compatible with the roof product. Discharge, run-off or contact with copper must be avoided with both plain and pre-painted roofing.

## 4.11.4 Hot Water Runoff Corrosion

The combination of hot water and copper is detrimental to all types of roofing, and hot water from copper pipes will exacerbate the corrosive effect of copper itself.

**Water from the exhaust pipes of hot water cylinders or pressure relief-valves must not be permitted to discharge onto metal roofs. The copper pipes of solar panels, air-conditioning or other ancillary equipment must be sealed to avoid runoff onto any metal cladding or gutters other than copper.**

## 4.11.5 Walkways

**Only aluminium, stainless steel, inert plastic, or hot-dipped galvanized steel framing members are acceptable for support structures above steel cladding and must be supported by the structural members or across the ribs of the profile adjacent to the ribs.  They should be designed to allow natural rain washing of the roof underneath.**

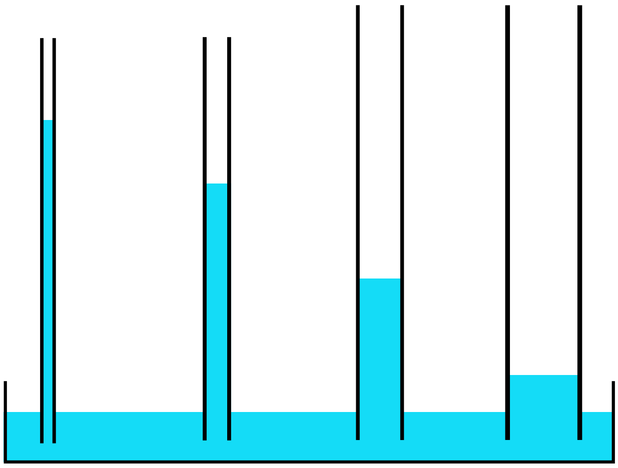
## 4.11.6 Capillary Action

While capillary action is both a durability and a weather tightness issue, it is considered here because it affects durability more often than water tightness, although the two are inter-related.

Capillary action is the ability of a liquid to flow into narrow spaces without the assistance of, and in opposition to, external forces such as gravity. It is caused by the combination of intermolecular forces of surface tension in the water and adhesive forces between the liquid and surrounding surfaces.

The effect can be seen in the drawing up of liquids between the bristles of a paintbrush, in absorbent materials such as blotting paper or a sponge, in a burning candle, a fountain pen, or the cells of a tree. The effect can occur in a tube, but also between two closely spaced mating surfaces.

## 4.11.6A Capillary Action



Gravity will affect the degree of capillary action; a low sloping pair of surfaces will attract liquid more by capillary action than a vertical surface, and a narrow tube will draw a liquid column higher than a wider tube.

**Capillary action is an important consideration in cladding installation and design, and can be considered in four main areas:**

1. **Closely stacked sheets of trapezoidal or corrugate profiles, or flat sheet that has the sheet ends exposed to rain, will draw water between the surfaces which can infiltrate a long way into the stack of material. After a short time in the absence of air, it can form volatile corrosive products which are unsightly and detrimental to product life.**
   **While metallic coatings have temporary surface protection against wet storage stain and organic coatings also give some protection, there is no hard and fast rule as to how long this will last; it is up to the roofing contractor to take appropriate measures. Packs of close stacked sheets exposed to water must be fillet or cross stacked to allow natural air movement and drying, before the onset of wet storage stain.**
2. **Capillary action can take place in the side lap of roofing sheets, or between a longitudinal flashing and the adjacent rib. For this reason, side laps should be designed with a capillary break, and when**

calculating the water carrying capacity of a profile, the allowable water depth is taken as being to the bottom of the capillary bead, not the rib height.

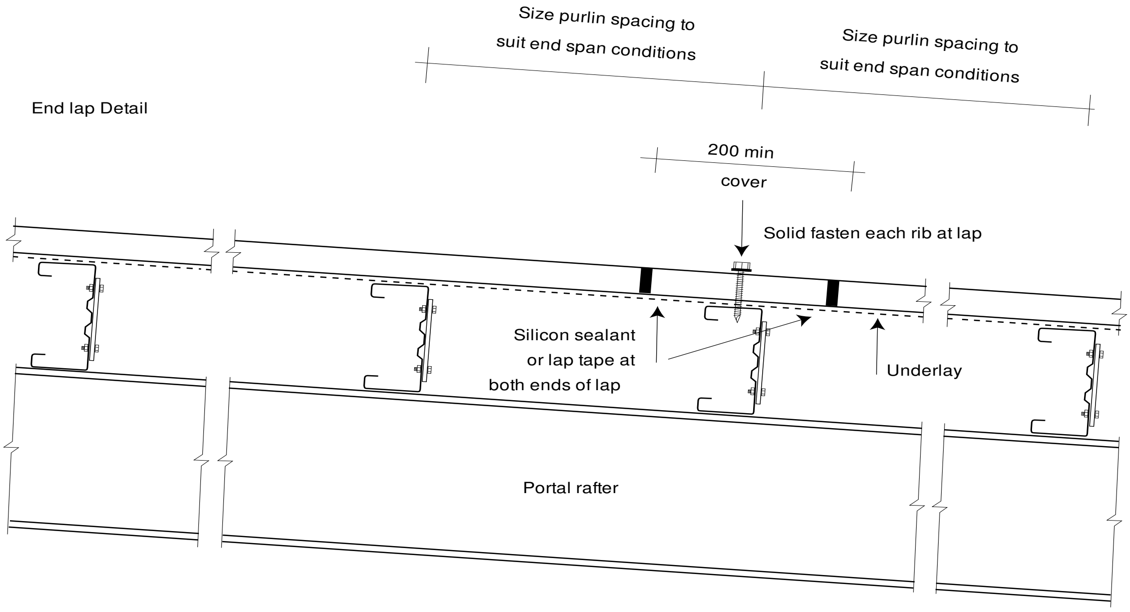
Even corrugate profiles are designed to have an asymmetrical shape between under and over crest. However, this is not normally as effective as the capillary break on a rib profile. This is one of the reasons why the minimum pitch for standard corrugate is 8°, although it has been proven to perform at lower pitches in short runs if the dimension of the overlap is not too generous and it is not extending into the water table.

With longitudinal flashings, such as barges, the downturn into the pan should not be tight against the rib, but have a gap to avoid capillary action from occurring.

3. Capillary action is also common between the end laps of sheets. When short run sheets were the norm and end laps common, the onset of corrosion normally occurred around the lap despite primer being applied to the surfaces. It was most often concentrated on the upper end of the lap and was caused, not by rain water, but by condensation on the underside of the sheet entering the lap.

   End laps on roofing should be avoided where possible. Where they do occur, end laps must be sealed at both ends to avoid ingress of moisture from both internal condensation and external rainfall, and end laps in vertical sheets must be sealed at the top end of the lap.

## 4.11.6B Capillary Action End Lap Detail




4. The adhesive nature of water that causes capillary action can help drive water up the underside of the sheets at the eaves, rather than discharging into the gutter. Therefore, the ends of all sheets laid to a fall less than 8° require a drip edge; and the minimum roof pitch of standard corrugate is 8°, as it is difficult to form a drip edge in that profile.The lower edge of all roofing sheets and flashings laid to a fall of less than 8° must be drip formed into the gutter to prevent capillary action.

## 4.11.7
## Crevice Corrosion/Wet Storage Stain

Roofing materials exposed to the air react with the atmosphere to form a relatively stable surface. Exposing metals to water in the absence air causes the formation of unstable surface films.

Crevice corrosion occurs in crevices and confined spaces. Crevices are often created because of overlapping flashing or sheets of cladding, or between the sheets of close stacked materials.

Design details that trap moisture, dirt, and debris should be avoided.

Corrosion can appear even with a chemically neutral electrolyte. An example of this type of corrosion is the corrosion on metals underneath paint coatings and "white rust" — the wet storage stain on closely nested zinc coated roofing sheets. Other metals, such as aluminium/zinc coated and non-ferrous metals, can suffer similar damage.

## 4.11.7A White Rust due to Capillary Action

Capillary action can cause white rust to occur throughout a length of cladding

## 4.11.7B Bulky Deposits of White Rust

White rust on galvanised sheets causes bulky white deposits to form that can quickly lead to red rust

If end-lapping of roof sheets cannot be avoided, both ends of the lap must be continuously sealed to ensure that neither condensation run-off from the under-surface nor rainwater run-off enters the lap.

Capillary action can cause water to be drawn into closely stacked sheets, resulting in crevice corrosion or wet storage stain on both metallic coated and non-ferrous materials. On metallic-coated steel sheets, the passivation coating gives some temporary protection against this process, as do organic coatings, but longevity cannot be guaranteed for the duration of this protection. On non-ferrous, metals, wet storage stain can commence very rapidly.

Wet packs of sheets should be separated to allow surfaces to dry before substantial storage.

If wet storage stain appears on unpainted surfaces, the degree of erosion of the metallic surface may be slight despite the bulky appearance of the deposits. However, when left unchecked it, can quite quickly lead to substantial degradation. If required, measurements can be taken of the thickness of the material or the metallic coating to determine the extent of erosion.

Even if the damage is superficial, the white deposits must be removed to allow exposure to the air to allow the normal formation of stable surface films. Use a stiff bristle brush; wire brushes are not recommended as they will remove more of the protective coating.

## 4.11.8 Microcracking

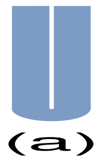
Microcracking is microscopic cracking on the surface.

- Microcracking of the metallic and/or organic coating creates a crevice where the normal protection mechanisms of the coating are compromised. It can lead to premature corrosion failure.

The test requirement for paint adhesion in AS/NZS 2728 and by the NZMRM is a bend test over a nominated number of material thicknesses (T) and it is measured as the internal diameter.

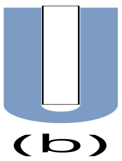
The radius required to avoid microcracking on metallic coated and pre-painted steel is measured externally. To obtain an external radius, add two material thicknesses to the internal diameter, and divide the result by two.

### 4.11.8A Microcracking : a



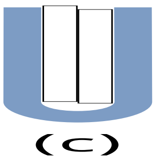

*0 T internal diameter = 1.0 T external radius*

### 4.11.8B Microcracking : b



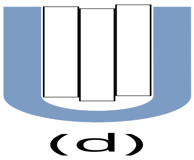

*(b) 1 T internal diameter = 1.5 T external radius*

### 4.11.8C Microcracking : c



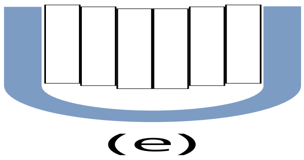

*(c) 2 T internal diameter = 2.0 T external radius*

## 4.11.8D Microcracking : d




*(d) 3 T internal diameter = 2.5 T external radius*

## 4.11.8E Microcracking : e




*(e) 6 T internal diameter = 4.0 T external radius*

## 4.12 Inert Catchment

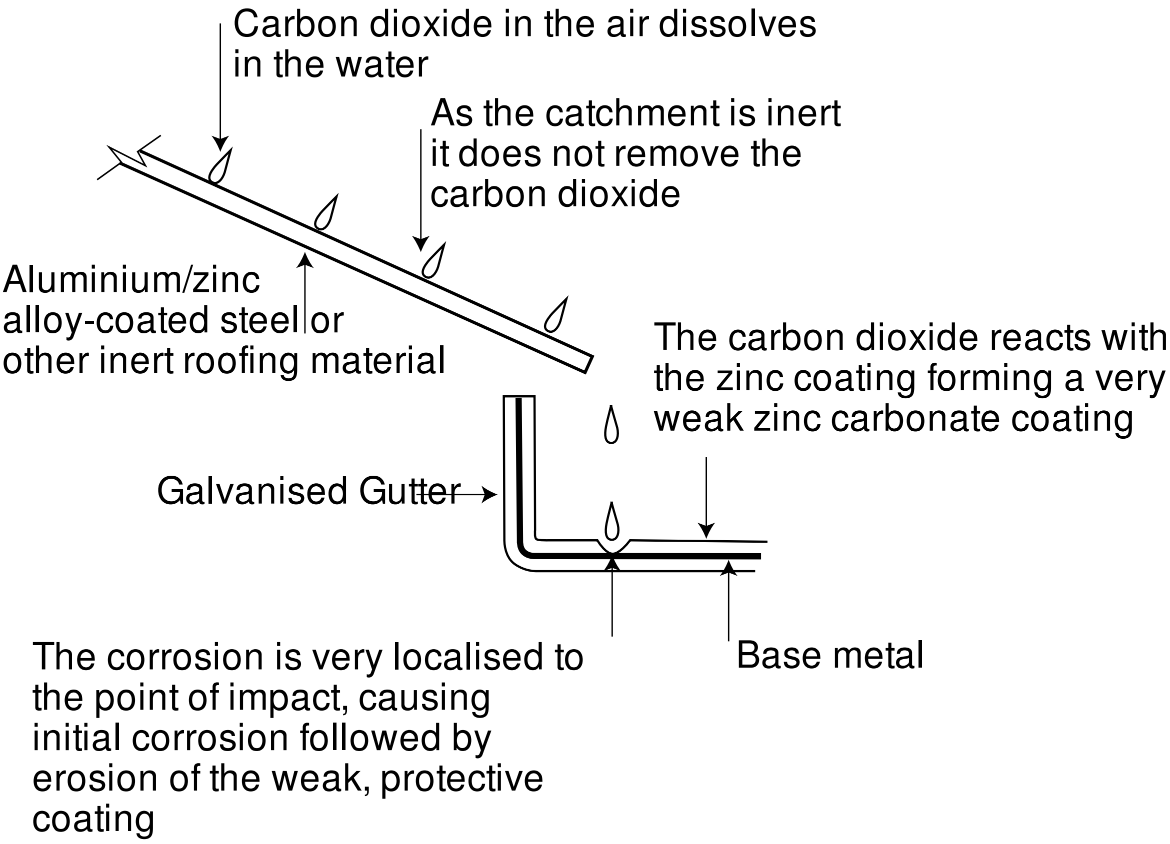
Run-off from inert surfaces such as glazed tiles, aluminium and aluminium-dominant metallic coatings, fibreglass, pre-coated metals, glass or any painted surface can cause corrosion of unpainted galvanised steel and other zinc-dominant metallic coatings. This is known as 'drip-spot corrosion' or inert catchment corrosion.

Water sitting on a surface absorbs carbon dioxide forming carbonic acid, which is reactive with zinc. On a galvanised surface, the carbonic acid reacts with the zinc and becomes neutral. On an inert surface discharging into an unprotected zinc surface, the carbonic acid is not neutralised, and reaction will be concentrated on the drip points of the inert surface onto the zinc surface.

As the formation of carbonic acid takes time to occur, inert catchment corrosion is normally seen at specific drip points of dew off a roof, rather than below rain washed painted walls and windows.

## 4.12A Inert Catchment

## 4.12B Carbon Dioxide



## 4.13 Ponding

Ponding happens when water is unable to drain from a roof or gutter surface. Possible causes include lack of fall, poor penetration design, and damage to sheet ribs due to excessive spans or foot traffic. The accumulated water increases the time of wetness and can lead to poultice corrosion.

All paint systems on factory pre-painted materials are permeable to a degree and will delay, but not prevent, the corrosive effects of ponding.

Ponding can occur in gutters and spouting when joints or outlets are higher than the sole of the gutter, or when debris is left to accumulate.

To help prevent ponding, the minimum pitch for all metal roof cladding in New Zealand is set at 3°. At pitches of lesser pitches deflection of the structural members or settlement of the building can compromise drainage.

Low pitch roof spans must be sized according to the type and frequency of roof traffic to prevent ponding caused by rib damage, and penetration flashings must be of a free draining type.

# 4.14 Pitting Corrosion

Pitting corrosion is a highly localised corrosive attack that forms pits which have a very small surface area, but which can be quite deep.

Pitting occurs on non-ferrous metal when the protective passive film breaks down, or where it has been weakened or damaged by contamination. When the break-through occurs in the passive film, the actively corroding pit constitutes the anode and the large passive film surrounding the pit acts as a cathodic surface.

The rate of dissolution of the metal is strongly influenced by the ratio between anode and cathode areas, consequently the "driving force" behind pitting attack can be very strong and deterioration can spread quickly.

## 4.15 Swarf Staining and Cut Edge Corrosion

Swarf is the term given to the steel debris as a result of cutting or piercing a metal sheet or adjacent metal surfaces.

When cutting steel, any swarf remaining on the sheet starts corroding quickly and causes stains. These stains are often mistaken for early deterioration of the cladding.

To some degree, swarf will normally be evident at the completion of any roof cladding job. The acceptability of swarf depends on how it got there, whether techniques have been applied to minimize it, and the visual exposure of the cladding.

### 4.15A Light Scattered Swarf

Light, scattered swarf is acceptable in most situations.

### 4.15B Excessive Swarf

Swarf created by acceptable means of cutting — i.e., power drills, self-drilling screws and shears — will be either loose or lightly adhered to the surface film of painted or unpainted sheets. Most swarf can be removed by daily hosing, sweeping, or blowing which should be done at the end of each day and at the completion of the job.

Avoid blowing loose swarf under adjacent cover flashings.

Any remaining swarf will not be in contact with the metallic substrate and will not cause deterioration of the roof, its effect is aesthetic only.  Overly aggressive efforts to remove such swarf is likely to damage the appearance of the cladding without enhancing its durability

On highly visible surfaces, a soft rag and plastic spatula can be used to remove more tenacious swarf adhesions, or on painted surfaces, the use of a diluted mild household liquid cleaner might work.  Wire brushing, steel wool, or pot scouring cloths must not be used as they will damage the organic or metallic coating.

Swarf created by unacceptable practices, such as the use of grinders and friction power blades on, or adjacent to the cladding, is often hotter on contact with the cladding. The heat may cause it to embed deeply in the organic film and be in contact with the protective metallic substrate.

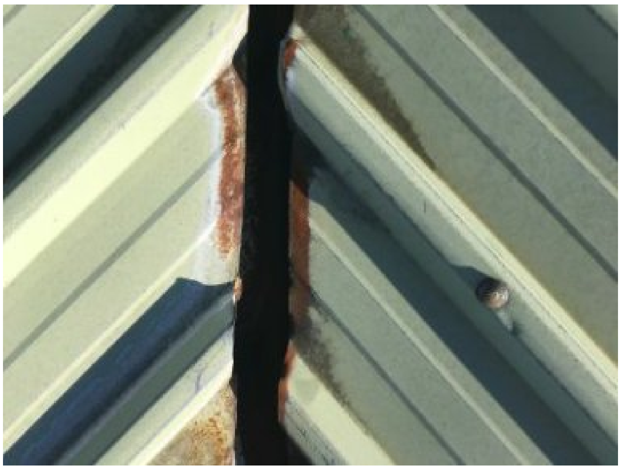
## 4.15C Friction Cut Edge

Friction cutting that creates swarf can also cause heat damage to metallic and organic protective surfaces.

This can severely affect the substrate; removal is difficult or impossible to achieve without mechanically damaging the decorative and/or protective coatings.

Swarf is not the only problem that cutting with friction blades can create. Such blades will often produce excessive heat at the cutting edge, which will degrade the organic and metallic coatings.

## 4.15D Cut Edge Corrosion



Often roof damage is caused by sub-trades accessing the roof after installation. Roofers and other trades must be aware of how they are treating the material they are working on and the effect it may have on adjacent surfaces.

Where work is done above or adjacent to an installed roof surface, or where the roof is used a work platform for subsequent work, the main contractor must take steps to make sure the existing roof remains undamaged.

## 4.15E Mechanical Damage

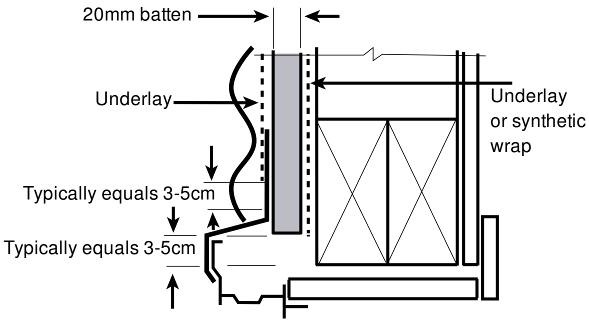
This roof shows evidence of mechanical damage to the coating, rib traffic damage to adjacent ribs within a purlin span, and excessive swarf by unacceptable cutting practices. In this case the only logical remedy was replacement.

## 4.16 Clearances

To ensure the edge of the flashing does not mechanically remove protective coatings on the cladding, there must be enough clearance between the edge of a vertical flashing, or a notched flashing, and the cladding. Similarly, the edges of cladding running parallel to flashings, such as at a window head, should have clearance to avoid mechanical damage and allow drainage.

Having the lower edges of flashings apart from the surface they are covering helps to improve the cut edge durability of the flashing. Kick-out barge details are preferred to bird's beak barge details for the same reason. The size of the clearance is not critical, but typically it is more than 5 mm.

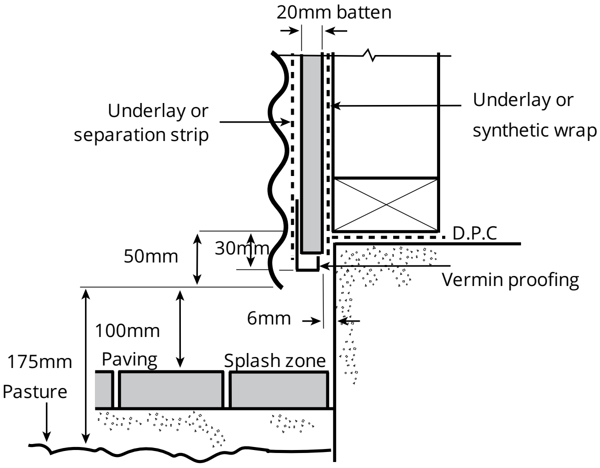
### 4.16A Window Head




## 4.16.1 Ground Clearance

Clearance is required between the bottom of profiled metal cladding and large flat surfaces. For timber-framed dwellings, E2/AS1 requires a clearance of 35 mm to an adjacent roof, 100 mm to paved ground, and 175 mm to unpaved ground.

## 4.16.1A Ground Clearance Detail




The clearance requirements for unlined buildings is less than that required for lined buildings, as the absence of lining enables the inner face of the cladding to dry more rapidly, and inspection and maintenance of the framing can be practically achieved.

## 4.16.1B Importance Levels from NZS 3604;2011 (Table 1.1)

| | |
|---|---|
| **Level 1** | Structures presenting a low degree of hazard to life and other property |
| **Level 2** | Normal structures and structures not in other importance levels |
| **Level 3** | Structures that may contain people in crowds or contents of high value to the community, or may prose risks to people in crowds. |
| **Level 4** | Structures with special post-disaster functions. |

## 4.16.1C Minimum Ground Clearance for Lined Buildings

**Minimum Design Ground Clearance for**
**Profiled Metal Cladding on Lined Buildings of Importance Level 2.**

| Ground Type | Minimum Clearance |
|---|---|
| Garage door opening | 25 mm |
| Walls under canopies | 35 mm |
| Paved | 100 mm |
| Unpaved gravel | 125 mm |
| Unpaved lawn | 150 mm |
| Unpaved pasture | 175 mm |

Importance level 1 buildings may have a lesser clearance provided occupant maintenance prevents the build-up of debris against the cladding.

Greater clearance may be required where gardens abut a wall, where lawn grasses are not grazed or maintained, or where soil spillage from adjacent banks may occur. Future landscaping effects on ground levels must also be considered.

## 4.16.2 Site Management

The effectiveness of clearances in achieving durability requirements is subject to the occupant ensuring that vegetation, debris, and soil do not build up against the cladding surface. Design clearance from a surface is no guarantee of durability as effective clearances are subject to site development, occupant behaviour and building maintenance.

### 4.16.2A Cladding Open to Air

*Cladding which is open to air will experience the normal wet/dry cycles for which it is designed.*

### 4.16.2B Vegetation in Contact with Cladding

*Vegetation or earth in contact with the cladding will increase the time of wetness and may contain corrosive compounds.*

The separation of profiled metal claddings from corrosive surfaces such as wet timber or concrete is more critical at the bottom end of cladding, where high humidity levels may be experienced for extended periods. This may take the form of a 3 to 6 mm gap, an inert self-adhesive tape or a PVC vermin strip.

Internal environments are also important, ventilation must be adequate for the building use, and absorptive of corrosive substances must not be in prolonged contact with the external or internal face of the cladding or structure.

## 4.16.2C The Result of Debris Build-up Against Cladding

*Allowing build-up of material against wall cladding can result in corrosion regardless of nominal ground clearance.*

## 4.17 Materials

Metals used in the roof and wall cladding industry in New Zealand are:

- steel coated with zinc - Galvanised steel;
- steel coated with an alloy of aluminium and zinc, sometimes with the inclusion of other minority elements;
- aluminium;
- copper;
- zinc;
- stainless steel; and
- lead.

*Many of these can coated with an organic coating, including acrylic, polyester and PVDF.

## 4.17.1 Steel

### 4.17.1.1 Metallic Coatings

For most of the nearly 200-year history of lightweight steel cladding, the protective metal coating has been made from zinc (usually with minor additions of other metals), and this is called galvanised steel. It works by the zinc sacrificing preferentially to the steel.

In the second half of the 20th century research looked for metallic coatings which would provide longer life. Aluminium was tried as a coating material because of its passive surface, but it was not satisfactory on its own. However, aluminium alloyed with zinc and other metals produced more corrosion proof products than any metal on its own. **(See 4.4.2 Barrier Protection.)**

We now have two groups of metallic coatings for steel cladding products — zinc-dominant coatings, which primarily provide sacrificial protection; and aluminium-dominant coatings, which primarily provide a barrier protective coating of aluminium oxide. Coatings containing both aluminium and zinc are now the preferred coating for roof and wall cladding products, although zinc-based coatings continue to predominate for various other products.

The composition and weights of these coatings are described in detail in AS 1397:2011. The following sections discuss metallic coatings in the order in which they appear in AS 1397, not their rate of use in the market.

#### 4.17.1.1.1 Coating Thickness

Steel was zinc-coated for many years by dipping short lengths of flat or profiled sheet metal in a bath of molten zinc, and the steel was then hung to cool while the excess zinc coating drained off.

More than sixty years ago manufacturers developed a continuous hot dipping method. During the continuous hot dipping process, the steel coil is run through a bath of molten metal. The thickness is controlled by blowing off the excess coating with air jets applied to both sides of the strip as it leaves the molten metal bath.

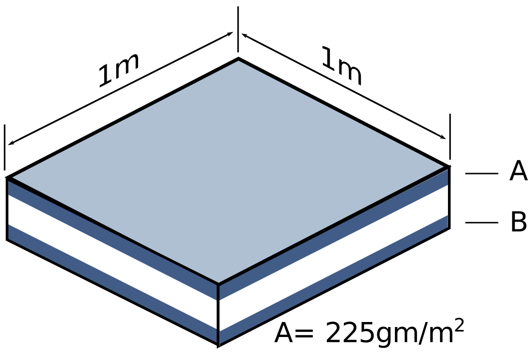
Continuous hot dipping, as opposed to the batch immersion process, is more cost-effective and allows for greater control of the consistency, thickness, and surface condition of the metallic coating.

It is a similar process to that for continuous paint coating, shown in 4.18.1.1 The Paintline Process, with priming, coating, and ovens replaced by the molten metal tank and blow-off section.

**The atmospheric corrosion performance of a hot-dipped zinc coating is closely proportional to its thickness.**

The thickness of coatings in micrometres (μm) can be measured with a non-destructive magnetic induction meter or similar device which can then be converted into grams per square metre (g/m²).

### 4.17.1.1.1A Coating Thickness




There is confusion about the method of describing the coating thickness of coil-coated sheet and strip products in g/m², compared to products that were hot-dipped after fabrication. The coating thickness of sheet and strip refers to the collective amount of coating on both sides of the sheet, effectively dividing the coating weight by half. It is invalid to equate the coating weight in g/m² of hot-dipped zinc coatings on fabricated products, such as nails and screws, with that of metallic coatings on sheet and coil; the coating thickness of the fabricated products relates to one surface only.

A micron (μm) is one-thousandth of a millimetre.

## 4.17.1.2 Galvanised Steel

Zinc Coating, commonly called galvanising, is still one of the most common metallic coating processes for steel. Galvanising describes various methods of adding a metallic zinc coating to steel to give it cathodic protection; also known as galvanic protection.

Galvanised steel is classed as a "Z"-coating and has a bold crystalline pattern or spangle, a random geometric pattern that resembles frost on a window.

There are many processes for galvanising, but only products dipped or immersed in a bath of molten zinc can be called hot-dipped galvanised, the process used for the metallic coating of steel roof and wall cladding.

The thickness of the coating can be more precisely controlled on a continuous coil galvanising-line than it can be with other methods.

The standard coating weight for unpainted galvanised coil and sheet used for roof and wall cladding is 450 g/m², designated Z450, but other coating weights are available. The coating weight for products intended for painting is 275g/m², and it is designated Z275.

Since the advent of ZM coatings, minimised spangle zinc coated products, typically used for painting, are now designated with the "M" after the weight, e.g., Z275M.

The process of zinc coating by electro-plating gives a much thinner protective film and is not considered suitable for painted or unpainted cladding materials exposed to the weather.

## 4.17.1.3 ZA Coatings

ZA coatings are a zinc-aluminium alloy coating consisting of 95 % zinc and 5% aluminium by mass, with the addition of lanthanides.  It is commonly known as Galfan® and is as designated ZA in AS/NZS 1397. As an European product it generally conforms to EN 10214..

ZA serves the same purpose as galvanised Z and AZ coatings, but has different corrosion characteristics than both.

ZA coatings are not currently available in NZ or Australia.

## 4.17.1.4 ZM Coatings

ZM coatings are zinc-aluminium alloy coatings with a majority of zinc and a small amount of magnesium. Steel with a continuously hot-dipped coating of zinc with 5 -13% aluminium and 2 - 4% magnesium is designated in AS 1397:2011 as ZM. In New Zealand, it is commonly marketed as ZAM.

The coating weights are similar to Zinc coatings, with ZM 240 used for products which will later be coil coated and ZM 450 for unpainted products.

Unpainted ZM products have been used for roofing accessory and rainwater cladding applications in New Zealand, but are more commonly found in factory pre-painted products.

## 4.17.1.5 AZ Coatings

AZ coatings are zinc-aluminium alloy coatings with a majority of aluminium. AZ coating, marketed as Zincalume® steel, is an alloy of zinc and aluminium which is now the most commonly used coating in New Zealand for protecting steel roof and wall cladding.

AZ coating is applied in the same way as other coatings, but with a pot temperature at about 140˚C higher than galvanised coating, and it is rapidly cooled to provide a dual-phase microstructure.

The alloy consists of 50 to 60% aluminium, zinc, and a small addition of silicon. In New Zealand, the ratio is nominally 55:45. These percentage ratios are by mass; by volume, the percentage ratio changes to approximately 80% aluminium and 20% zinc. Volume is probably a more realistic measure of its nature.

The alloy coating thickness generally used for steel roof and wall cladding is 150 g/m² (AZ150). This coating is approximately the same thickness (0.04 mm) as Z275 zinc. AZ200 coatings are available as a substrate for organic coated products to be used in very severe environments.

An AZ coating protects steel both as a barrier and sacrificially, as the aluminium content provides a barrier, while the zinc content of the coating will sacrifice itself to protect the base steel.

The AZ coating is finer grained than zinc alone and has a silver matt hue with a lightly visible spangle. This finish has a relatively high level of initial reflectivity, which darkens over time.

A thin acrylic film is applied during manufacture in New Zealand. The acrylic film acts as a roll forming lubricant and minimises finger marking and surface discolouration.

## 4.17.1.6 AM Coatings

Adding magnesium to an aluminium dominant zinc-aluminium alloy coating improves the cut edge corrosion resistance to a similar level as zinc coating, but still confers the improved surface protection and slower erosion rate of AZ coatings.

Steel with a continuously hot-dipped coating of 47 - 57% aluminium and zinc, with the addition of 1 - 3% magnesium by mass is designated in AS 1397:2011 as AM. It is not currently sold in NZ but is under test.

Coating weights may be AM100, AM 125 or AM150.

## 4.17.2 Stainless Steel

Stainless steel is a durable, corrosion-resistant material used in harsh environments when a non-weathering finish is desired. Chromium forms a tenacious oxide protective film on stainless steel that is transparent and self-healing, as it will repair itself on exposure to the atmosphere.

Stainless steels are resistant to most chemicals, but are subject to crevice and pit corrosion (see Wet Storage).

**Some light surface staining known as tea staining may appear, but it is not damaging to the product.**

Most stainless steel roof and wall cladding, flashings and panels in New Zealand are made from the 300 series of austenitic non-magnetic stainless steel, which contain chromium, nickel, and manganese, with 304 and 316 being the most common grades.

Grade 304 stainless steel is an alloy of 18% chromium and 8% nickel that provides high corrosion resistance and is known as an all-purpose alloy.

Grade 316 stainless steel should be specified where tea staining must be avoided. It contains 16% chromium, 10% nickel, with 2% molybdenum added, which increases resistance to staining and corrosion.

Grade 445 ferritic stainless steel is now available in New Zealand, which combines the corrosion resistance of grade 316 with formability approaching that of carbon steel. As the work hardening of 445 is much lower than with austenitic grades, it can be formed in a similar way to carbon steel and is more easily sheared.

Grade 445 stainless steel contains 22% chromium and 1.2% molybdenum and no nickel. It has lower thermal expansion than other grades, so it is less likely to distort in the heat of the sun. The yield stress and hardness of 445 is higher than 304 and 316, but the tensile strength and elongation properties are lower.

**The corrosion resistance grade of 445 is similar to grade 316 in most marine and aggressive industrial environments.**

Stainless steel is available in various mill finishes from dull matt to highly polished. The most common finishes for roof cladding and sheet metal flashings, are those designated as 2B and 2D.

The 2B finish is a bright, cold-rolled finish that is highly reflective and 2D is a dull finish that is less reflective. BA is a bright reflective surface only suitable for decorative cladding in thicker gauges. Embossed patterns are available that reduce visible distortion and minimise glare and reflection.

Stainless steel should not be cleaned with steel wool, but stainless steel wool or synthetic abrasive pads can be used. Cleaning should be done with care as roughening the surface may promote further stains.

Stainless steel fixings should be used with stainless steel sheet to avoid dissimilar metal corrosion. The fastener grade must match the grade of the cladding.

There is no well-defined yield point for stainless steels. Fully annealed or standard annealed tempers are used for ease of forming with 304 and 316 having an approximate yield strength of 290 mPa.

Austenitic stainless steels require different forming techniques than other metals, and are known to be tougher and more difficult to form than carbon steel of the same thickness, e.g.,m when shearing stainless steel the equipment capacity should be increased between 30% - 50%. Because of the toughness of the metal, sharp cutting edges dull more quickly than when used with carbon steel.

Although stainless steel is not much harder than mild steel, increased power is necessary to form it because of its high ultimate strength and its higher work hardening rate. As most forming machines are rated for the heaviest gauge steel this capacity should be de-rated by 40%.

Precautions should be taken not to contaminate the surface of the metal by inclusions from roll forming or folding equipment. It can appear as rust spots on stainless steel, which is detrimental to performance. Stainless steel coil and sheet can be supplied with a strippable film on both faces to avoid this contamination.

## 4.17.3 Aluminium

The aluminium alloys used in New Zealand for roof and wall cladding are included in the 5000 series.

- Aluminium 5005 has excellent workability, weldability and corrosion resistance.
- Aluminium 5052 is a higher strength marine grade alloy with exceptional resistance to corrosion in marine or industrial environments.

Following strain-hardening of aluminium alloys, tempering increases the ductility by low-temperature heating, and their description regarding hardness relates to the last number, e.g. H12 or H32.

The description of tempers given to aluminium alloys can be confusing because the different alloys are strain hardened in different ways. As a result, different alloys with the same hardness description may have significantly different yield strengths.

Pure aluminium (99%) can be used as a soft edging for ridge or apron flashings required to act as a wind barrier.

Aluminium alloys are available in three surface finishes.

- Mill finish: A smooth, lustrous finish which will dull relatively quickly.
- Stucco Finish: An embossed mill finish, which reduces the specular reflectance of mill finish sheet.
- Painted Finish: A range of painted finishes are available similar to those offered in painted steel.

The high reflectance and emissivity of unpainted aluminium can reduce heat transmission considerably.

Aluminium develops a thin oxide film on the surface that is impermeable to most airborne contaminants, except for strong alkalis and acids.

### 4.17.3A Aluminium Hardness End-use

| Note: Typical stocking of 5052 alloy, H36 allows for rollforming both corrugate and trapezoidal profiles. Trough section may require H34 material. H36 material can be used to manufacture most flashings, except those requiring soft edging or hemming. | | |
|---|---|---|
| **Alloy;** | **Yield Minimum** | **Typical Use** |
| **5005 – H32 Quarter Hard** | 85 | Lockseam |
| **5005 – H34 Half Hard** | 105 | Folding |
| **5052 – H32 Quarter Hard** | 160 | Lockseam |
| **5052 – H34 Half Hard** | 180 | Folding and curving |
| **5052 – H36 Three Quarters Hard** | 200 | Rollforming and folding |
| **5052 – Fully Hard220** | 220 | Rollforming |

## 4.17.4 Zinc

Zinc is a traditional roof cladding material and weathers to a dark grey patina after environmental exposure, like galvanised steel, except there is no spangle effect on the surface. Zinc roof panels and flashings are commonly 0.7 mm thick, although heavier gauges can be used. Zinc roofs are usually fully supported on sarking.

The staining potential of zinc run-off onto other surfaces is less than that of copper and lead. Flat zinc panels must be adequately vented from underneath and are available with a high-build lacquer coating to help prevent corrosion of the under-surface.

Zinc has approximately twice the thermal expansion coefficient as steel, so allowance for expansion must be made accordingly.

Under 7 °C the metal becomes brittle and is difficult to form without fracturing.

Zinc used for roof cladding generally contains small percentages of titanium and copper, which add to the properties of pure zinc.

Zinc is also available in a range of pre-patinated surfaces.

## 4.17.5 Copper

Copper is a naturally durable product.

Copper grades 122, 110, and 102 may be used in construction. Grade 122 is the most commonly used; it has been deoxidized with phosphorus, which makes it weldable. The other grades cannot be welded but can be soldered.

Copper darkens in reaction to the atmosphere. Near seawater or industrial sources of sulphur-containing gases, a green patina may develop in time. In different environments, the weathered colour may vary from dark brown to almost black.

Copper-containing alloys, such as brass and bronze, are available when different colours are requested or for accessories requiring greater strength.

Copper is more malleable than steel sheets, and annealed copper is used for hand folding or where a high degree of formability is required. Roll formed roofing, wall cladding, gutters, spouts, and flashings are typically made from half hard copper. Copper roofs are normally fully supported on sarking.

Copper must be protected from contamination when being processed with tools that have been used to process other metals because the resulting inclusions might cause pit corrosion.

Neither copper nor run-off from copper should come in contact with less noble metals, as it will cause galvanic corrosion. Avoid installing copper in contact with or receiving run-off from bituminous material or other acidic surfaces, because it prevents the formation of the protective patina, causing discolouration and a shortened lifespan.

## 4.17.6 Lead

Historically, lead has been a popular choice for roof cladding and flashings, because it is naturally durable and is easily shaped using hand tools at ambient temperatures, without the need for softening or annealing.

Lead has an inherent lack of mechanical strength and is laid on solid sarking. It has high thermal movement and, over time, there is a risk of distortion and lead sheet cracking. Sheet lead is available in weights from 6 kg/m² to 40 kg/m².

**The thinner the lead, the shorter the length should be. A maximum length of 1500 mm or less than 1.5 m² is ideal.**

Run-off from a new lead roof can stain other metals with a white lead carbonate. Application of a proprietary product or boiled linseed oil and mineral turpentine mixture can avoid that happening.

A factory applied cured coating that inhibits the contact between lead and oxides with water is available. The lack of contact reduces the potential for run-off staining other metals, and of lead entering ground water systems. Avoid using lead roofs to collect potable water.

## 4.17.7 Translucent Sheeting

Translucent sheeting should be manufactured from naturally durable products or have a protective surface film to avoid ultra-violet degradation. (See Natural light for more information.)

## 4.17.8 GRP

GRP is a composite material made up of polyester resin, reinforced with glass fibres.  It is protected from UV erosion by a surface coating consisting of a gel or laminate.  The composite is extruded and set over forming moulds to match specific roofing profiles.

GRP can often be used as translucent sheeting or it can be supplied with a clear, or opaque gel coat to the weather surface to provide a high level of corrosion resistance to aggressive atmospheres, where coated metal or even non-ferrous metals may not perform as required.

Examples of use can be found in extreme environments such as wool scouring plants, fertilizer stores, tanneries, acid plants and smelters, abattoirs, compost plants, galvanizing plants, and buildings in harsh geothermal areas.

Where an entire roof is clad in GRP, (rather than individual sheets separated by metal sheets as in a typical case of translucent sheeting), it affects the trafficability and safety requirements. If a GRP roof is required to be accessible, it can be manufactured incorporating woven roving reinforcement into the resin matrix to make it trafficable. Another option would be to install stainless steel safety mesh under the roof cladding, if required.

# 4.18 Organic Coating

## 4.18.1 Pre-painted Factory Finish

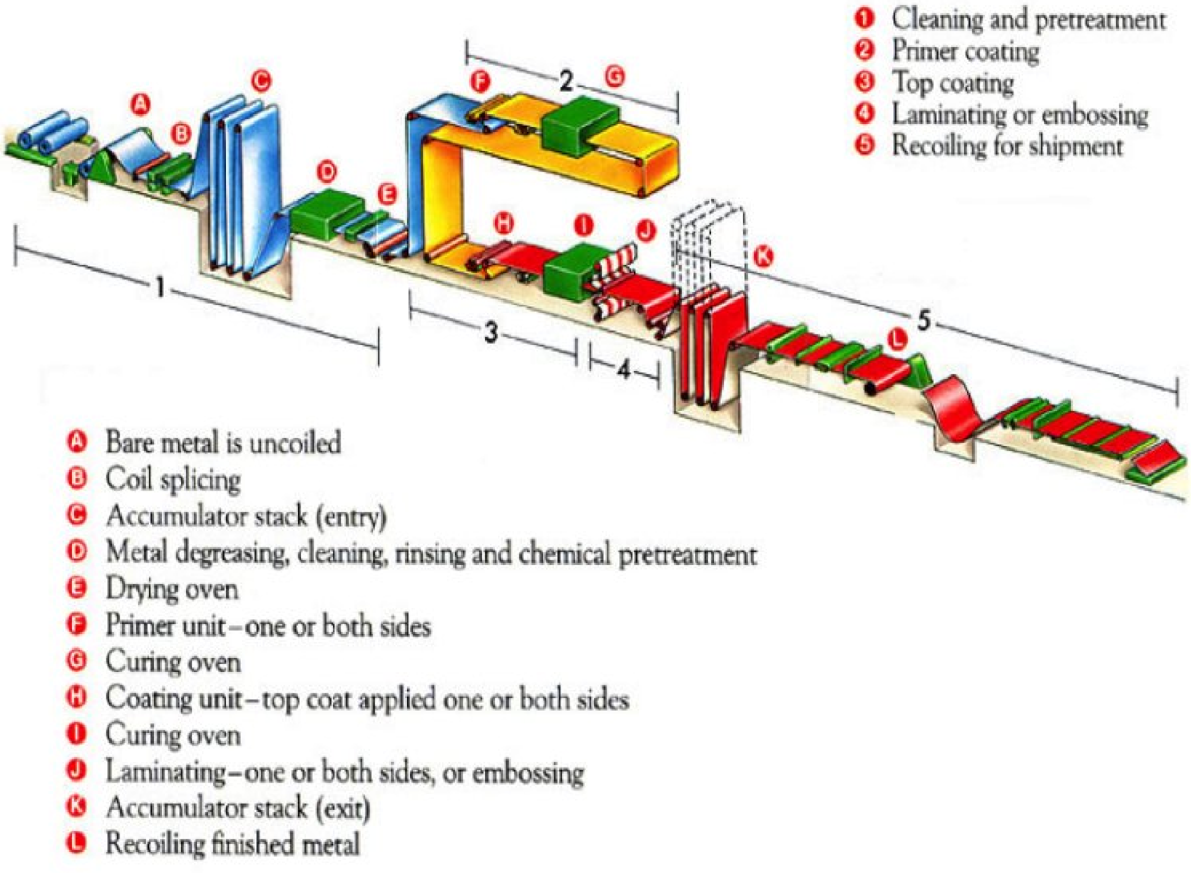
The performance of metallic coated profiled metal can be enhanced by the application of an organic ("paint") coating. In pre-painted steel coil this is applied continuously as a two-part primer/topcoat system, prior to the material being roll formed into profile.

The different combinations of metallic coating/primer/topcoat all have different characteristics and must be matched to the material and the environment in which they are to be exposed.

The primer and the topcoat have different performance requirements to fulfil.

### 4.18.1.1 The Paintline Process

#### 4.18.1.1A The Paintline Process



## 4.18.1.2 Primer

The purpose of the primer is to adhere to both the substrate and the topcoat, and to give added corrosion protection. Primers used on coated steel coil have anti-corrosive pigments which inhibits corrosion through an electro-chemical reaction.

## 4.18.1.3 Top Coat and Backer

This is the outer skin and it must give the desired appearance. In terms of durability, it provides a measure of barrier coating while still being breathable, and prevents UV degradation of the primer.

Functionally the top coat must be hard enough to prevent excessive marring during profiling and installation; and when in use, it must:

- be flexible enough to form to relatively tight bends without excessive micro-cracking;
- be resistant to fade in NZ's harsh environment;
- withstand extremes of temperature; and
- be a suitable surface for the collection of potable water.

More recent innovations include solar reflectance technology to minimise the amount of solar heat gain gathered by the cladding

Backer coats generally have the same primer and a thinner top coat than the upper surface. Double-sided systems can be specified for areas where the underside is seen, but in external environments these will be exposed to salt spray and other contaminants, and it cannot be assumed that the underside will last as long as the rain washed top surface — even with regular maintenance.

As paint formulations from different suppliers may have different performance characteristics, it is important that cladding and accessories are supplied from the same manufacturer as differing weathering characteristics may result in visible variance in appearance.

Surface coating must comply with AS/NZS 2728. Cladding and flashings must come from the same source and have the same coating specification, so that fade rates are similar. Fade rates must not exceed those stipulated in AS/NZS 2728. All coatings must be lead free and suitable for the collection of drinking water.

AS/NZS 2728 has been deemed ambiguous in that it can be interpreted as allowing accelerated testing to determine colour fastness and durability. Such tests have been found to be an unreliable indication of a system's performance in real-life situations. MRM has therefore adopted an interpretation of this standard as the compliance standard for its members. In the MRM standard, the four-year real-life testing for durability and colour fastness are clarified as being Normative (Compulsory).

## 4.18.2 Post-Painted Factory Applied finish

This coating system is most commonly used for pressed metal tiles.

Where a coating is applied to a Metallic coated steel or Aluminium substrate after the profile of the roofing sheet has been formed is referred to as a Post-Painted Factory Applied Finish. The metallic substrate may have a coil coated primer, coil coated anti-finger print coating, a factory applied post painted primer or be cleaned and treated to suit the application of the coatings in a factory environment.

Post Painted coating applied to the substrate vary from smooth matt or gloss painted finishes and textured granule finishes bonded to the substrate with high build coatings. The dry film builds are high compared to pre-primed or coil coated products and the films seal any micro-cracking of the metallic coating that may have occurred in the forming process.

The corrosion performance of the post painted factory applied finished products is influenced by the substrate. The use of Aluminium Zinc metallic coating (AZ) has been proven to work extremely well with the post painted finishes in almost all environments.

The coatings are durable with expected first time recoating maintenance of over 15 years. Touch up of these coatings is possible as the same coating formulation used can be applied in the field. As with any organic coating there will be a gradual breakdown of the resin systems which may result in chalking of the surface.

Chalking is the result of erosion of the surface coating and slight colour changes may occur as the surface resin is eroded. The extent of change depends on pigments used and also the gloss level, a coating that started out as a matt finish will change very little while a gloss finish will appear to have changed more.

Granule-textured finishes use crushed rock that is either natural or natural rock with the surface coated with a ceramic coating that incorporates light-fast inorganic pigments. Both the natural rock and ceramic coated granules provide exceptional long term colour durability. The coatings used to adhere the granules to the substrate are designed to be flexible in all environments and, although durable, the coating is protected from UV by the UV opaque granules.

A clear coating is applied to the granules during the coating process, which helps bond the granules into the adhesive base coating and provides a robust surface reducing any damage during the transportation and installation process. As this clear coat weathers, it exposes the natural or coated surface of the granules, which is slightly duller than the initial finish.

## 4.18.3 Powder Coating

Powder coating is generally used to colour match accessories used with pre-painted steel cladding and rainwater goods. The use of powder coating on metallic coated steel roof and wall cladding and flashings is not recommended for the following reasons.

- It will fade at a noticeably different rate to adjacent pre-painted metal surfaces.
- Powder coated products are length limited by the size of the curing oven and cannot be re-formed after coating.
- Drilling or cutting of the sheet after powder coating will create an exposed edge vulnerable to under-cut corrosion.
- Standard powder coating does not have the corrosion resistance of pre-painted metal and is vulnerable to post coating damage and edge creep corrosion.
- It is difficult to obtain adhesion to powder coated surfaces when overpainting, and the remaining powder coat surface may not provide a good substrate for such.

Power coating may be used to colour match accessories but cannot be relied upon to increase durability, unless specific pre-treatment and powder coating systems are specified and applied.

## 4.18.4 Lap Priming

End laps should be avoided where possible. Side laps on profiled sheets do not require priming as they are designed with capillary grooves to drain naturally, or other means to avoid the accumulation of condensation or rainwater.

## 4.19 Accessories

### 4.19.1 Fastener Durability

All cladding fasteners must be compatible with the material, suitable for the environment and a durability equivalent to that of the cladding material. All exposed fasteners must have a minimum durability of Class 4. (See 17 Testing)

Only aluminium or stainless steel screws and washers should be used on pre-painted aluminium roof and wall cladding. Stainless steel fasteners must not be allowed to come into contact with the cladding and should be installed through oversize holes.

Sealing washers must be non-conductive to prevent electrical contact between the screw, the metal washer and the cladding surface.

Steel cladding screws can be subject to hydrogen embrittlement when they are hot dipped galvanised. Alternative methods of galvanising, such as peen plating and other metallic coatings, are generally used in combination with an organic coating.

Care should be taken to minimise damage to the head of the nail or screw when using colour matched painted hot-dipped galvanised nails, bolts and screws.

Sandblasting in exposed conditions can significantly reduce the coating thickness and the longevity of the fastener.

Premature failure can result when the shanks of the screws and the eaves purlin are exposed to sea spray, and a high-fronted gutter is recommended to help prevent this.

The performance of the shank of the fastener is also affected by internal environments when the contaminant is inside the building, e.g., animal shelters, fertiliser works.

All fasteners should be easily identified by a code stamped on the head to identify the manufacturer and the coating class.

### 4.19.2 Screw Guns

To avoid damage to the coating to the screw-head, drivers should not be of the impact type and should be fitted with a snug fitting driver bit.

### 4.19.3 Sealant

Sealant should be neutral cure silicone or MS polymer.

### 4.19.4 Underlay

Underlay should have durability no less than the cladding material, and be compatible in contact with the roofing material.

### 4.19.5 Underlay Support

Galvanised wire netting or mesh can be used to support underlay where the internal environment is not aggressive, but is not to be used with painted aluminium.

Plastic mesh, tape or string may be used to give support at a maximum of 300 mm centres. These alternatives should be used when underlay support is required with aluminium cladding. Ensure that the underlay-support fasteners do not come in contact with the underside of the cladding.

For buildings with harsh internal environments, stainless steel, or PVC-coated mesh and netting are available. PVC-coated mesh may suffer degradation from UV radiation if used externally or when it is exposed to high levels of direct or reflected sunlight.

# 5 Roof Drainage

The Roof Drainage section coincides with the NZBC Clause E1 Surface Water. It describes how to drain rainwater from roofs quickly and effectively. Topics include:

- Rainfall Intensity
- Roof Pitch for Drainage
- Gutter and Downpipe Design
- Gutter and Downpipe capacity calculations.

## 5.1
## NZBC: Clause E1 — Surface Water

**Objective**

Safeguard people from injury or illness, and property from damage, caused by surface water

**Functional Requirement**

Buildings and sitework shall be constructed in a way that protects people and other property from the adverse effect of Surface Water.

**Performance**

Surface water resulting from an event with a 2% probability of occurring annually shall not enter buildings.

## 5.2 Roof Drainage Design

*The roof drainage system for a building consists of four separate parts:*

- *gutter or spouting;*
- *outlet, sump, rain-water head;*
- *downpipe; and*
- *drain.*

N.B. Ground drainage is outside the scope of this Code of Practice.

*This section specifies good trade practice for the design of roof drainage systems including eaves, valley and box gutters, sumps, rain-water heads and downpipes based on the Average Recurrence Interval (ARI) (see 8.2.) and the applicable catchment area calculations.*

*The objective of roof drainage systems is to maintain a weatherproof building, to minimise the risk of injury or inconvenience due to flooding, and to avoid potential monetary loss and property damage—including the contents of buildings.*

*Any seepage can lead to dampness that encourages the growth of moulds, some of which are detrimental to health. Flooding, not necessarily related to the intensity of rainfall or the design of the drainage system, is often caused by gutter or spouting blockages as a result of inadequate regular cleaning and inspection. Drainage systems, as described in this section, will not perform as required without on-going maintenance. See 16 Maintenance .*

Roof drainage design requires consideration of the following:

- rainfall intensity;
- catchment area;
- cross-sectional gutter area;
- sump design;
- the cross-sectional area of downpipes;
- water disposal from downpipes;
- overflows;
- roof cladding profile capacity;
- roof pitch; and
- penetrations which obstruct water flow.

## 5.3 Rainfall Intensity

**When calculating roof drainage where significant inconvenience or injury to people or damage to property, including building contents, is unlikely—e.g., due to an overflow of external eaves gutters— the Average Recurrence Interval (ARI) used must be 10 years.**

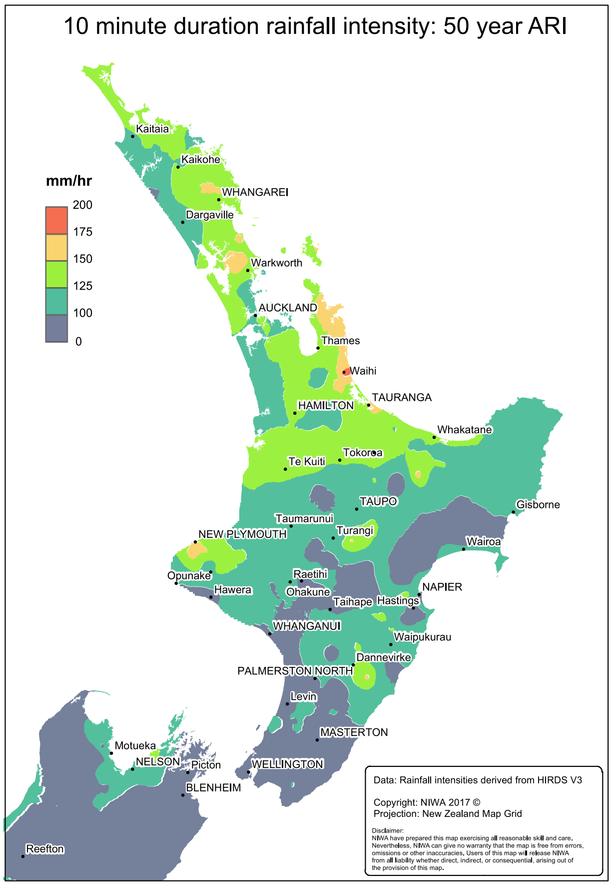
**When calculating roof drainage where significant inconvenience or injury to people or damage to property, including building contents, is likely—e.g., due to an overflow of internal gutters—the Average Recurrence Interval (ARI) used must be 50 years.**

*A higher level of rainfall should be allowed when designing for higher risk situations.*
*The rainfall intensity in New Zealand is determined by the rainfall during a ten minute period, measured in millimetres per hour.*

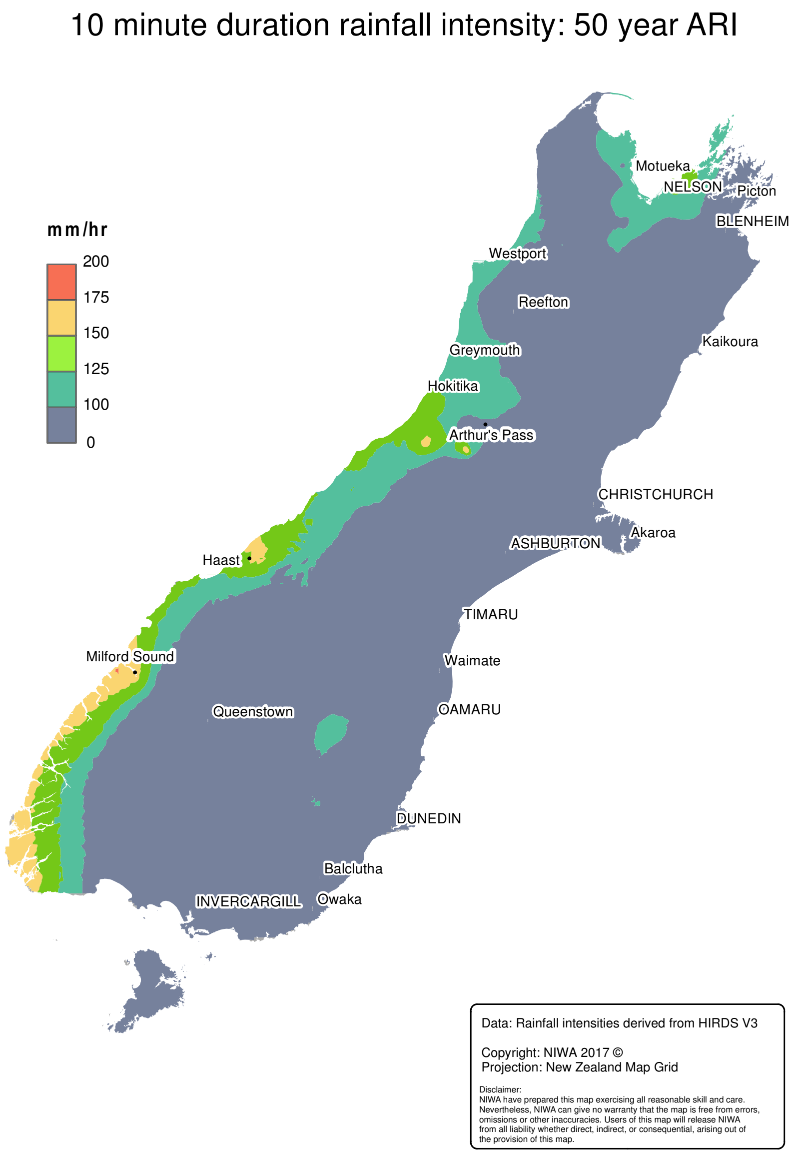
*Although a rainfall of (for example) 17 mm in ten minutes (that equals 100 mm/hr) is unlikely, the equivalent of 3 mm in two minutes is likely and is, therefore, used as a basis to avoid flooding.*

The MRM COP publishes 10 min rainfall for instensity maps for both islands as a quick reference. Rainfall Intensity information for a specific site can be obtained using the High Intensity Rainfall Design System (HIRDS) tool from NIWA at: https://hirds.niwa.co.nz/

## 5.3A New Zealand Rainfall Intensity Map



## 5.3B South Island 10 min Rainfall Intensity: 50 year ARI




The 5.3A New Zealand Rainfall Intensity Map shows areas with a 10% probability that rainfall will exceed the specified amount over a ten-minute duration for an ARI of fifty years.

During rainstorms, long periods of steady rainfall are interspersed with heavy downpours for short periods and the roof-drainage system should be capable of handling the peak intensities without flooding.

On large low pitched roofs, there is a considerable time-delay between the onset of rain and when the water drains at the downpipe. This time lag changes the rate of flow capacity needed for the gutter and downpipe to drain without overflow.

Gutter overflow is acceptable on eaves-gutters or freely discharging downpipes if they are designed to do so, but it is unacceptable from internal gutters or downpipes.

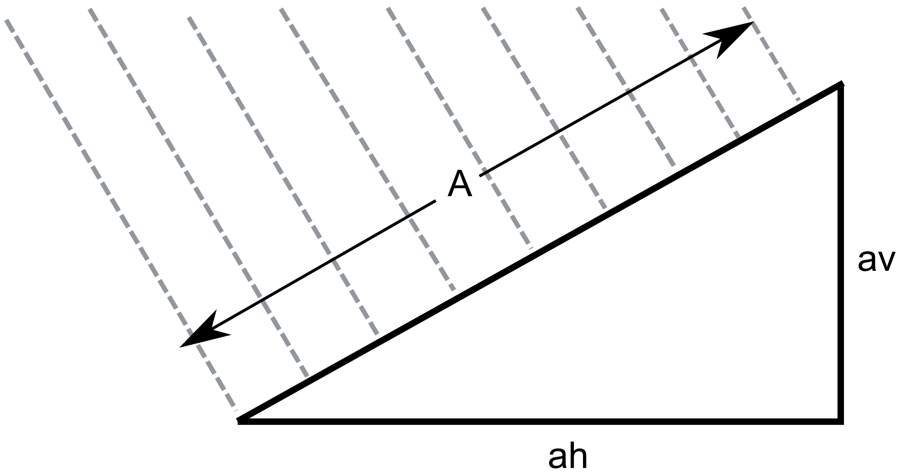
When the site rainfall intensity shown on the 5.3A New Zealand Rainfall Intensity Map is greater than 100 mm/h, the gutter and downpipe cross-section areas must be proportionally increased as prescribed in 5.3.2 Capacity Calculations.

## 5.3.1 Catchment Area

The rain catchment area for a roof, or roof and wall, is determined by the direction of wind-driven rain; it depends on the fall angle of the rain and walls next to the roof.

The effect of wind on rainfall needs to be calculated for all roofs with a pitch greater than 10°, using a slope of 2:1 for the calculation.

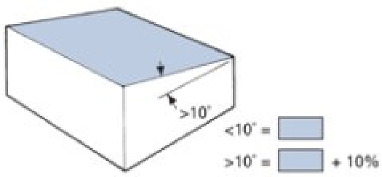
### 5.3.1A Wind-effect on Rain




*The roof catchment area needs to be adjusted because rain is usually accompanied by wind, which can increase the catchment area. There are various formulae and slope factors that can be used to determine the specific wind drift effect for each building, some of which are shown in AS/NZS 3500.*
*The formulae quoted in this C.O.P. assumes the worst scenario and provides a conservative answer because shielding would decrease the catchment area when the wind is in the opposite direction,*

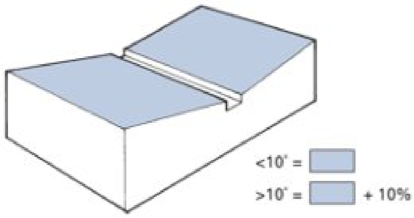
*The sloped roof catchment area for all sloped roofs which has a pitch of more than 10° and is freely exposed to the wind, must be increased by 10% to allow for the wind drift effect.*

### 5.3.1B Sloped Roof Catchment Area



*For multiple roofs, some allowance can be made for shielding, but in the interests of simplicity—and because of the permutations of roof pitch and length—the sum of the sloped roof areas will give a conservative figure the internal gutter capacity calculation.*

## 5.3.1C Multiple Roofs Catchment Area

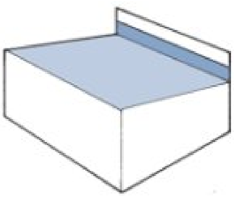



*There are three ways to calculate the catchment area for roofs with a vertical wall next to the roof slope.*

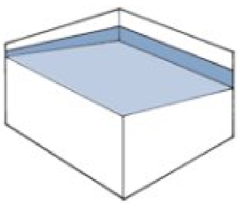
- *Where the roof pitch is less than 10°, the catchment area is the sum of the sloped surface area and 1/2 of the vertical wall surface area. See 5.3.1D Roof with a Wall.*
- *Where the roof pitch is more than 10°, the catchment area is the sum of 1.1 multiplied by the sloped surface area and 1/2 of the vertical wall surface area. See 5.3.1D Roof with a Wall.*
- *Where there are vertical walls at right angles to each other, the catchment area is the sum of the sloped surface area and 1/2 of both the vertical wall surface areas. See 5.3.1E Roof with Two Walls.*

*The catchment area for high vertical walls, such as a multi-storey building, may be considerably less than half its surface area.*

## 5.3.1D Roof with a Wall



## 5.3.1E Roof with Two Walls



*When a high vertical wall added next to an existing gutter, it is likely that the gutter capacity would be overloaded. In this case either the increased catchment area should be drained separately or the gutter should be redesigned.*

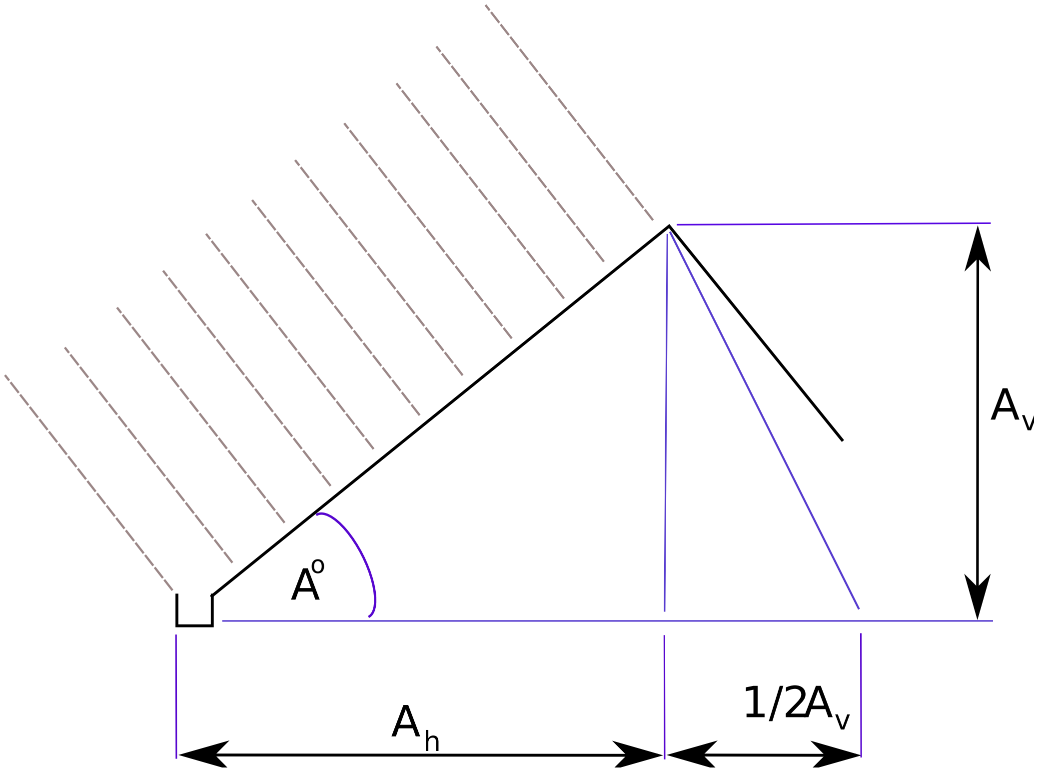
## 5.3.1F Catchment Area Calculation

| | | |
|---|---|---|
| All roofs freely exposed to the wind | <10° | =sloped roof area |
| Sloped roofs freely exposed to the wind | >10° | =sloped roof area x 1.1 |
| Vertical wall/adjacent to the roof slope | <10 | =sloped roof area + 1/2 wall area |
| Vertical wall adjacent to the roof slope | >10° | -sloped roof area + 1/2 wall area x 1.1 |

*After the catchment area has been determined by using Table 8.2.1, the capacity of the gutters and downpipes can be calculated by two simplified methods:*

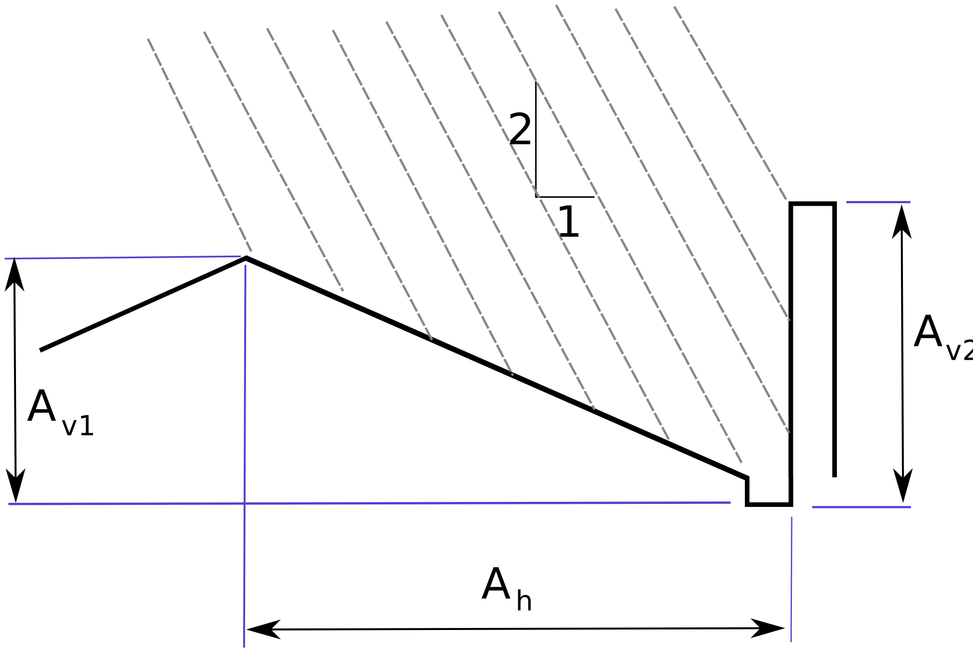
- *Method 1 Graph for pitches <10°. (See graph 8.2.2.)*
- *Method 2 Calculations for any pitch.*

## 5.3.1G Single Sloping Roof




*Catchment: A=Ah + 0.5 Av*

## 5.3.1H Vertical Wall with Sloping Roof




*Catchment A = Ah+ 0.5(Av2-Av1)*

## 5.3.2 Capacity Calculations

Because the roof pitch, length of run, gutter and downpipe size, shape and fall are all interrelated in the determination of the capacity of each other, the calculations in sizing these components can be complicated.

Assumptions can be made to provide a conservative and simple assessment of the capacity of spouting, gutter and downpipe for roof drainage by two methods.

### 5.3.2.1 Method 1: Gutter and Downpipe Capacity Determined by Graph

When using the simplified capacity calculation graphs, the following assumptions have been made.

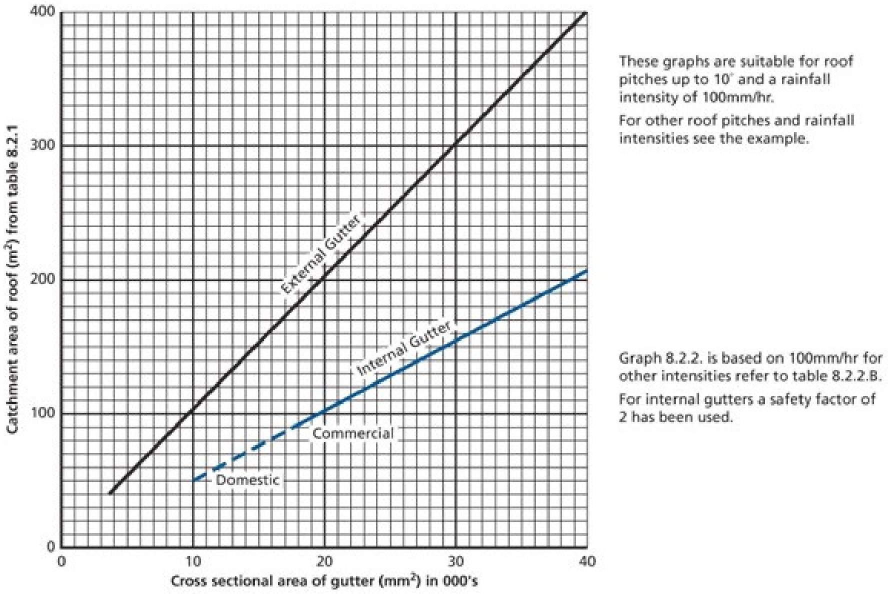
- roof pitches are 3° – 10° (for greater pitch see 5.2.2.3A Roof Pitch Adjustments);
- the roof area is 50m² – 300m²;
- the minimum cross-sectional area of gutter is 4000mm²;
- flat gutter or spouting (for design purposes only);
- there are no restrictions — no spouting, gutter or downpipe angles;
- free discharge — weir into a sump or rainwater head with overflow;
- the rainfall intensity is 100mm/h (for greater rainfall see 5.3.2.3A Cross-sectional Area per m2 for rainfall

of 100 mm/h); and

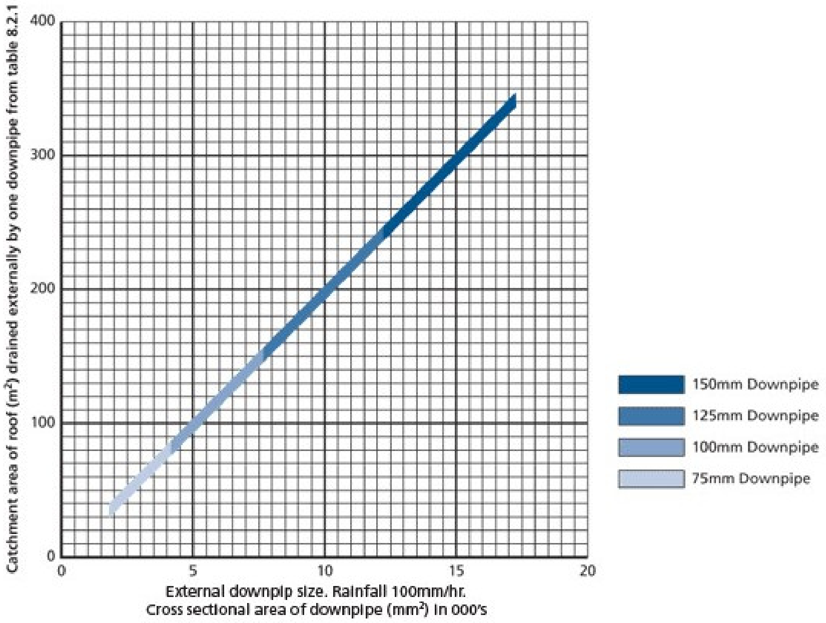
- external vertical downpipes.

Given these assumptions, the design capacity of gutters and downpipes is given in the following graphs.

### 5.3.2.1A Cross-sectional Area of Gutter




### 5.3.2.1B Downpipe Size



## 5.3.2.2 Roof Pitch

### 5.3.2.2A Roof Pitch Factors

| | | |
|---|---|---|
| 10° - 25° | multiply by a factor | 1.1 |
| 25° - 35° | multiply by a factor | 1.2 |
| 35° - 45° | multiply by a factor | 1.3 |
| 45° - 55° | multiply by a factor | 1.4 |

### 5.3.2.2B Example Calculation (Finding Capacities Using the Simplified method)

| | | | |
|---|---|---|---|
| Given | Freely exposed mono-slope roof | | |
| | Tauranga | | |
| | Sloping rafter length 5.9 m | | |
| | Length of building 10 m | | |
| | Roof pitch 24° | | |
| Step 1: | From Rainfall Intensity Map | rainfall = 150 mm/hr | |
| Step 2: | From Table 2 | factor = 1.5 | |
| Step 3: | Roof pitch from table 3 | factor = 1.1 | |
| Step 4 | To find the factorised catchment area from Catchment Area Calculation Table | | |
| | 59 $m^2$ x 1.1 | = 65 $m^2$ | |
| | 65 x 1.5 x 1.1 | = 107 $m^2$ | |
| Step 5 | External gutter | = 10 0 $mm^2$ x 107 | = 10,700 $mm^2$ |
| | Internal gutter | = 200 $mm^2$ x 107 | = 21,400 $mm^2$ |
| | Vertical downpipe | = 50 $mm^2$ x 107 | = 5,350 $mm^2$ |
| | Horizontal downpipe <15° | = 100 $mm^2$ x 107 | = 10,700 $mm^2$ |
| Step 6 | From Table 8.2.2.3. Find suitable spouting and downpipe. | | |

## 5.3.2.3 Method 2: Gutter and Downpipe Capacity Determined by Calculations

After the catchment area has been determined by 5.3.1F Catchment Area Calculation, the capacity of the gutters and downpipes can be determined by using the tables below.

### 5.3.2.3A Cross-sectional Area per m2 for rainfall of 100 mm/h

| | |
|---|---|
| external gutter or spouting | = 100 mm² |
| internal gutter | = 200 mm² |
| vertical external downpipe | = 50 mm² |
| horizontal downpipe <15° | = 100 mm² |

For rainfall of more than 100 mm/h the catchment area must be factorised to allow for the increased rainfall in line with the Rainfall Intensity Map.

### 5.3.2.3B Rainfall

| | | |
|---|---|---|
| 80mm/hr | multiply by a factor | 0.8 |
| 100mm/hr | multiply by a factor | 1.0 |
| 150mm/hr | multiply by a factor | 1.5 |
| 200mm/hr | multiply by a factor | 2.0 |

### 5.3.2.3C Pitches

| | | |
|---|---|---|
| 10° – 25° | Multiply by a factor | 1.1 |
| 25° – 35° | Multiply by a factor | 1.2 |
| 35° – 45° | Multiply by a factor | 1.3 |
| 45° – 55° | Multiply by a factor | 1.4 |

## 5.3.2.3D Example Calculation (Finding Capacities Using the Simplified method)

| | | | |
|---|---|---|---|
| Given | Freely exposed mono-slope roof | | |
| | Tauranga | | |
| | Sloping rafter length 5.9 m | | |
| | Length of building 10 m | | |
| | Roof pitch 24° | | |
| Step 1: | From 5.3A New Zealand Rainfall Intensity Map | rainfall = 150 mm/hr | |
| | From 5.3.2.3B Rainfall | factor = 1.5 | |
| Step 2: | From 5.3.2.3C Pitches | factor = 1.1 | |
| Step 3 | To find the factorised catchment area from Catchment Area Calculation Table | | |
| | 59 m² x 1.1 | = 65 m² | |
| Calculation | 65 x 1.5 x 1.1 | = 107 m² | |
| | External gutter | = 10 0 mm² x 107 | = 10,700 mm² |
| | Internal gutter | = 200 mm² x 107 | = 21,400 mm² |
| | Vertical downpipe | = 50 mm² x 107 | = 5,350 mm² |
| | Horizontal downpipe <15° | = 100 mm² x 107 | = 10,700 mm² |
| Step 4 | From Table 8.2.2.3. Find suitable spouting and downpipe. | | |
| | External Gutter or Spouting | = standard 175 rectangular | OK |
| | One vertical downpipe | = 100mm round or 100mm x 75 | OK |
| OR | 1/4 round with two downpipes | (one at either end see drawing 8.2.2.) | OK |
| | Two vertical downpipes | = 63mm round | OK |
| Step 5 | Internal gutter | = custom-made = 220 x 100 = 22,000 | OK |

## 5.3.2.3E Standard Gutter Capacity

| Size | mm² |
|---|---|
| 125mm 1/4 round | 5 000 |
| 125mm x 75mm rectangular | 9 375 |
| 175mm x 125mm rectangular | 21 875 |
| 300mm x 125mm rectangular | 37 500 |

## 5.3.2.3F Standard Down Pipe Capacity

| Round | Size (mm2) | Rectangular/square | Size (mm2) |
|---|---|---|---|
| 65mm | 3 318 | 100 x 50 mm | 4 500 |
| 80mm | 5 027 | 100 x 75 mm | 6 750 |
| 100mm | 7 854 | 100 x 100 mm | 9 000 |
| 125mm | 12 272 | | |
| 150mm | 17 671 | N.B. square and rectangular downpipe capacities have been depreciated by 10%) | |

An internal gutter normally requires 20 mm freeboard but using this simplified method to calculate catchment for in areas with a rainfall of more than100 mm/hr, and having a catchment basis of 200 mm/hr, an internal gutter would be over-designed if additional freeboard was added.

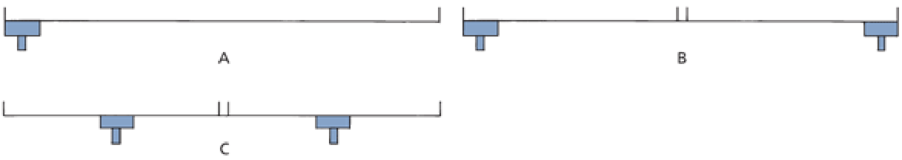
Similarly, internal downpipes, having no overflow to the exterior of the building, could be under-designed and their capacity should be increased by 25%.

N.B. Flooding is usually the result of a faulty drain, rather than the downpipe.

*For domestic and small commercial buildings standard spouting, gutters and downpipes are the most economical way to comply with the capacity requirements, but if large gutters are neededthey should be custom made.*

*The position of the outlet can make a significant difference to the size of the gutters and downpipes*

## 5.3.2.3G Gutter Capacity




As can be seen 5.3.2.3G Gutter Capacity in , when the catchment area is identical, the gutter capacity at A can be reduced by half at B and to one quarter at C. The downpipe capacity required at both B and C is half that of A.

The preferred proportion for an internal gutter is 2:1, i.e., the sole of the gutter should be twice the height. The minimum height of an internal gutter should be 70mm, but the recommended height is 1/60 of the length.

The recommended maximum length of a coated steel gutter, without an expansion provision, should be 12 m. However, 6 m can be the maximum length if the outlets are spaced at 12 m as shown in 5.3.2.3G Gutter Capacity. Non-ferrous metal gutters have length restrictions on their length based on their thickness.

When an external spouting has a dropper outlet or an external angle, the capacity of the spouting should be lowered by 10% for each outlet or angle. Outlets should be placed within 2 m of an angle.

**Dropper outlets must not be used on internal gutters.**
**Sumps or rainwater heads must be used to drain all internal gutters and must, also, be placed at gutter angles.**

## 5.3.3 Roof Cladding Capacity

The capacity of metal cladding profiles is determined by their geometry, the roof pitch and rainfall.

*The height of the lap is the determining factor for overflow and water ingress. Therefore, the lap should be sealed if it is below minimum pitch, as is required for curved roofs and bull-nosed verandahs.*

*All New Zealand manufactured roof cladding profiles, except corrugate, have adequate free discharge capacity for a rainfall of 100 mm/hr. Corrugate should be restricted to a maximum length of 40 m or a 30 m² catchment area for a rainfall of 100 mm/hr, or decreased or increased dependent on the rainfall.*
*(see section 8.2. catchment area)*

*Where the rainfall is greater than 100 mm/hr, sheets are longer than 40 m or multiple roofs are designed, it is recommended to increase the minimum pitch by 1° per 10 m over 40 m.*

A step in the roof, or any penetration, will require an increase in the drainage capacity of the profile required.

**Where multiple roofs are drained directly or indirectly onto a lower roof, the total catchment area is the sum of both roof areas.**

**When penetrations concentrate the run-off into one or more corrugations or pans, the capacity must be calculated as described in 9.5.3 Discharge Capacity.**

## 5.4 Snow

The installation of metal roof cladding in snow areas does not require any increase in the capacity of gutters, but it does require the installation of snow guards, so the gutter will remain free to drain the melt-water. As the gutter needs to withstand the dead load when it is full of water, and because the weight of snow will be less than that of water, no additional strength is required in the gutter if snowboards are provided.

*Gutters without snow guards are vulnerable to leakage because they can be blocked by snow, but with snow guards, the size of the openings should allow melted snow to escape.*
In snow areas, all internal gutters must have snow guards. See 3.8 Snow Loads.

The UDL imposed by the additional weight of snow will vary because one m³ of fresh snow weighs approx 100 kgs or a load of 1 kN. Fresh snow will be partially melted by rain and will be a combination of ice and snow. See 3.8 Snow Loads.

*Because one m³ of ice weighs approximately 900 kg (or a load of 9 kPa) and one m³ of fresh snow weighs approx 100 kg (or a load of 1 kPa), it is reasonable to assume that approximately 100 mm of snow on roof cladding will impose a load of 0.5 kPa. (50% snow/ice)*

*When temperatures are prolonged at sub-zero, melt-water can refreeze and build-up as an ice dam, particularly if the roof is insulated. In such conditions, to prevent the ingress of water, an impermeable membrane should be installed and supported between the last two purlins to discharge into the gutter.*

Purlin spacings should be reduced at the eave to allow for the added snow load, which is likely to be greatest at this position.

**In snow areas, the snow load must be added to the downward wind load, and purlin spacings must be reduced at both end and intermediate spans by the amount as shown on the load span graphs. See 3.16.5 Wind Load Span Graphs**

Special designs are required for spoutings and their supports in snow areas. See 5.5.2 Gutter Support Systems.

Leakage due to snow can occur at penetrations that are not designed in accordance with this Code of Practice.

Penetrations such as chimneys or vents from a heated building should be placed at a ridge or in the peripheral area around the roof because diurnal temperature fluctuations can provide a freeze/thaw cycle that will severely test any sealed hole in the middle of the roof cladding.

All penetration flashings larger than 600 mm in width in snow areas must use a cricket or diverter design. See 9.7.7 Diverter Or Cricket Designs

Snow loads are subject to variation due to drift and melting, and roof areas expected to trap significant quantities of snow present complex loading patterns. The design loads should take account of drifting of snow due to wind, but wind loads need not be combined with the snow load.

Roofs with internal gutters, valleys or high parapets, saw tooth or barrel vault roofs, can all retain accumulated snow through drifting due to wind and sliding snow. Where snow can be expected to accumulate, or where the shedding of snow is prevented, special loading should be applied as snow slide and drift can impose a load of up to two or three times greater than normal on the roof cladding and the structure.

Projections such as gutters, flashings and chimneys present obstructions that accumulate snow, and should also have special designs to resist loads from sliding snow.

When an additional building is to be built alongside an existing one, or where it is likely that snow can slide onto a lower roof, a revision of the original roof design loadings must be made.

## 5.4.1 Hail

Like snow, hail can cause blockage and subsequent leakage. For this reason, sumps and rainwater heads should have leaf guards that are the same size as the sump, provide a large free overflow area and should not be tapered, because of the wedging action of hail.

Snow gutter boards should be provided for all internal gutters, as a baffle, to allow hail melt water to drain safely without overflowing the gutter.

In all areas prone to hail—spouting, gutters, and their supports—should have additional fixings. See 5.5.2 Gutter Support Systems.

## 5.5 Gutters

**External gutters must be installed with the back lower than the fascia board or cladding.**

**External and internal gutters must have a cross-sectional area in accordance with 5.3.2.1A Cross-sectional Area of Gutter, and sumps, rainwater heads and downpipes must not restrict the flow from the gutter.**

For design purposes, gutters are assumed to be level. It is not recommended to obtain fall by tapering, as it reduces the cross-sectional area of the gutter.

With the limited fall available it is not always possible to ensure that all internal or external gutters will remain dry without ponding and so, to avoid premature corrosion, consideration should be given to using non-ferrous metals. See 5.5.8 Fall.

Unpainted galvanised steel is not guaranteed for spouting and gutters.

Because dirt retains moisture and causes corrosion, ponding voids warranties.

**All AZ coated steel spouting and gutters must be maintained to prevent ponding due to the collection of debris or dirt as required in 16 Maintenance .**

**Where their renewal within 15 years would be difficult, AZ-coated or pre-painted steel must not be used for internal gutters.**

All gutters are subject to expansion and, therefore, there is a maximum recommended length before an expansion joint is needed. The maximum length is determined by the metal, its thickness and colour. It is similar to the limit recommendations for roof cladding but should not exceed 12 m. See 7.3.2 Roof Cladding Expansion Provisions.
N.B. A sump or spouting angle provides sufficient movement for expansion.

Where a spouting or gutter can move freely and independently the increase in length should be according to the specifications in 14.5.3A Sliding Washers .

Sliding washers and the spouting or gutter should be of a cross-sectional dimension capable of resisting expansion forces. Copper or aluminium spouting or guttering that has been softened by brazing is not suitable for an extended length.

Outlets are only required at twice the length module because an expansion joint can be either a sump, rainwater head or a saddle flashing. See 5.3.2.3G Gutter Capacity.

### 5.5.1 Gutter Installation

No fixings should penetrate the gutter, because they prevent free movement of the gutter.

Gutters must not return, be folded back under the roof cladding, or be fastened to it because that prevents free thermal movement and expansion. All internal gutters must be hooked.

**The roof cladding must overhang the gutter by not less than 50 mm, with a down-turned drip edge when the pitch is less than8°. All internal gutters must have a flat sole to avoid premature corrosion caused by the accumulation of dirt and debris.**

A separate over–flashing is recommended:

- in coastal environments;
- where the pitch of the roof is less than 8° and in a very high wind design load area; and
- when the gutter does not shelter the profile. (see 8.4.4.4 Eaves Flashing)

Turn-downs are formed at the end of the cladding, over the gutter, to prevent water blowing back along the underside of the roofing. (See 5.8.2 Outlets and Overflows)

## 5.5.2 Gutter Support Systems

**The gutter bracket system must withstand the potential weight of a gutter full of water.**

**External spouting or gutters in snow load areas must be fitted with snow straps and brackets at a maximum of 600 mm centres to withstand the additional potential weight of any build-up of snow.**

Snow may slide off the roof if its pitch is less than 15°. When it is likely to happen over doorways, snow guards should be provided and fixed to the structure above. (see 3.8 Snow Loads)

All bracket material should be compatible with the gutter material, and brackets for pre-painted gutters should be painted or powder-coated before installation.

**Brackets must be installed to ensure a gutter gradient towards the outlets. (see 5.5.8 Fall)**

**The support system for internal box gutters must be flat, able to support the gutter when it is full of water, and withstand a point load of 1.1 kN.**

To prevent permanent deflection of the gutter, full support for the sole of an internal gutter should be provided by either a plywood lining or by close ribbed sheets of roof cladding, both of which require an underlay to reduce condensation. Underlay is also used to protect metal from the effects of timber treatment.

Brackets should be located at all stop-ends, at both ends of sumps, and at rain-heads at a maximum of 750 mm spacings for external gutters less than 180 mm wide, and at 600 mm centres for gutters 180 - 300 mm wide.

## 5.5.3 Eaves Gutters

External domestic guttering, also known as spouting, is available in standard profiles and in long lengths from the manufacturer, or in some areas made to length on site.

*The useful cross-sectional area of an external gutter is governed by the back height and not by the often-high front profile.*

Eaves gutter systems, including downpipes, must be designed so that water cannot flow back inside the building.

*Permanent leaf guards do not provide the protection claimed and assumed for metal gutters. Although they do prevent large pieces of debris from obstructing the outlets, they allow finer particles to collect on the sole of the* *guttering. The continual wetting of the interface between any debris and the metal will lead to early corrosion if regular maintenance is not carried out. Decaying organic matter such as leaves can produce organic acids, which will accelerate corrosion.*

Vertical outlets to eave gutters or spouting must have an area equal to half the cross-sectional area of the gutter and horizontal outlets must have an area equal to the cross-sectional area of the gutter.

Eave gutters should have an outlet within 2 m of an external corner; where it is impossible, eave gutters should be given additional fall to avoid ponding. Any change of direction can negate the fall of lengths up to 6 m and the number of outlets will be determined by the catchment area.

All eaves gutters should allow free expansion to occur. Such joints can be either a sump, rainwater head, or a saddle flashing, but they should not be fastened to the gutter. See 5.5.4A Internal Gutters

## 5.5.4 Internal Gutters

**When internal gutters are difficult to replace, and their failure could cause major disruption to the building below, they must be made from materials that will last 50 years to comply with the NZBC.**

**Only non-ferrous metals or alternative materials must be used, because coated steels do not meet these criteria.**

Suitable non-ferrous metals include 0.9 mm aluminium, 0.6 mm stainless steel, and 0.6 mm copper. Contact between coated metal products and copper or stainless steel must be avoided, because it leads to early corrosion. Splashback or run-off from copper onto coated metal must create the same problem.

Both internal and external gutters can be economically designed by positioning the outlets at quarter points as shown in 5.3.2.3G Gutter Capacity . Positioning the outlets as shown can also provide additional fall.

Internal, parapet or box gutters are subject to the same requirements as eaves gutters except, being internally situated, they are designed with a greater safety factor based on an ARI of 50 years, and a minimum design rainfall intensity of 200 mm/hr.

The overall depth of the gutter should be greater than that required by the design capacity to prevent the gutter overflowing by splashing or by standing waves from winds.

**For commercial and industrial buildings, internal box gutters must have a minimum depth of 70 mm. Internal box gutters for domestic buildings must have a minimum depth of 45 mm. All internal gutters must be able to withstand 1.1 kN point load.**

**Internal gutters must be provided with a weir outlet and discharge to a rainhead or sump to provide full drainage without ponding.**

**All sumps or rainheads must have an overflow, and the bottom of the overflow must be below the sole of the gutter.(see. 5.8.2 Outlets and Overflows**

**A freeboard allowance of 20 mm must be added to the net capacity calculation to increase the maximum depth of flow in internal gutters.**

**Within a building area, it is not permissible to sharply change the direction of flow of an internal gutter. Where two buildings meet at an angle, each gutter must be drained separately. This does not apply to**

**valley gutters.**

**Horizontal or back outlets must not discharge directly from the gutter, because they restrict the capacity of the gutter. (see 5.6.2 Bifurcated Valleys)**

When a scupper gutter-overflow is used at the stop-end or high end, the lowest level of the overflow should be located at a minimum of three-quarters of the height of the gutter. At the outlet end, a weir overflow at the level of the sole of the gutter should discharge into a sump or rain-head.

Scupper outlets should be avoided where possible. They are difficult to weatherproof, and they can inhibit expansion.

The sump for internal gutters is usually at a column with downpipe bends close to the sump. Sharp bends of less than 15° cause restricted flow into the downpipe and reduces the downpipe capacity. In this case, the downpipe size should be increased to that of the cross-sectional area of the gutter.

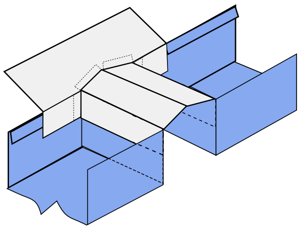
Internal gutters should have an expansion joint at the stop-end as shown in 5.5.4 Internal Gutters

When using net capacity and not the simplified calculation method, a freeboard allowance of 20 mm should be added to the net capacity calculation to increase the maximum depth of flow in internal gutters.

It is better practice to provide internal gutters with a minimum width of 300 mm for commercial and industrial buildings, and a minimum width of 200 mm for domestic buildings.

For maintenance purposes and general access, internal gutters are assumed to be capable of supporting a traffic load.

### 5.5.4A Internal Gutters



## 5.5.5 Fascia Gutters

A fascia gutter is an eaves gutter with a high front that shields the ends of the profiled cladding from view.

**The fascia gutter design must ensure that water cannot enter the soffit, or overflow into the building if the gutter system outlet becomes blocked.**

**Where a fascia gutter system is not easily replaced, and cannot be seen or provide any fall, it must be designed using non-ferrous metals or alternative materials to comply with the durability requirements of the NZBC. (see 5.5.8 Fall).**

**Overflow slots or an alternative overflow system must be added to concealed gutter systems where the back of the gutter is lower than the front. Overflows must be able to discharge the total amount of water from the roof catchment area. (see 5.8.2 Outlets and Overflows)**

## 5.5.6 Concealed Gutter Systems

Concealed gutter systems are proprietary systems that can be used with or without a fascia.

External fascia systems with internal gutters have brackets nailed or screwed to the soffit bearers or rafters providing gutter support. When the external fascia is spring clipped to the brackets, it conceals both the brackets and the gutter. The fascia has a soffit groove that accommodates a 6 mm soffit lining, and it should be installed before the roof is fixed.

The concealed gutter design must ensure that water cannot enter the soffit or overflow into the building if the gutter system outlet becomes blocked.

**Where a concealed gutter system is not easily replaced and cannot be seen, or cannot provide any fall, it must be designed using non-ferrous metals or alternative materials to comply with the durability requirements of the NZBC. (see 5.5.8 Fall)**
**Overflows must be provided for concealed gutter systems within 1 m of either side of the downpipe to discharge through the soffit immediately behind the fascia, and they should be capable of discharging the total catchment area served by the downpipe. For overflows see5.8.2 Outlets and Overflows**

**Where a valley, downpipe or other water source discharges into a concealed gutter, provision must be made for an overflow within 2 m of the turbulence that is created by such a discharge.**

The external fascia system can be used as a matching gable flashing and as a fascia with an external gutter or spouting.

## 5.5.7 Secret Gutters

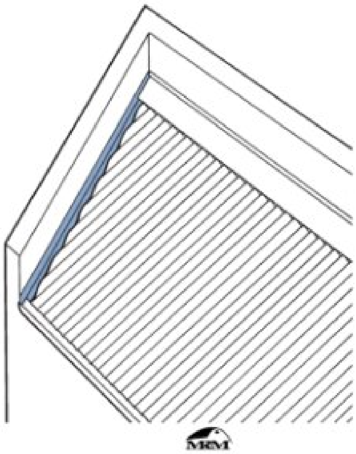
A secret gutter is used where the roof edge runs at an obtuse angle to a wall or parapet and drainage is required for the roof cladding tapering to the barge.

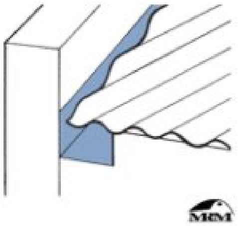
**Because secret gutters are difficult to replace and their failure could go undetected, they must be made from non-ferrous metals and be compatible with the roof material as shown in 8.4.5.1 Lockseamed Flashings**

**A valley gutter where the roof pitch more than 12° is regarded as a secret valley gutter. (see 5.6 Valley Gutters and 8.6.5 Valley Flashings. When the roof pitch is less than 12°, a sunken secret gutter must have a minimum depth of 45 mm and be designed in accordance with Rainfall Intensity.**

Because it is hidden from view, sufficient space and fall should be provided for this type of gutter to be self-cleaning. The COP recommends that a secret gutter should terminate at a rainwater head.

## 5.5.7A Secret Gutters with Parapet Wall





## 5.5.8 Fall

All metal internal gutters must have a minimum fall of 1:200 (5 mm in 1 m) and all metal eaves gutters must have a minimum fall of 1:500 (2 mm in 1 m).

For external gutters, drainage can improve significantly if there is a weir outlet, but regular maintenance is required to avoid notable ponding. With trees close by, significant ponding is likely to occur in spouting without leaf guards. For easy gutter maintenance, leaf guards should not be permanently fixed to the roof cladding.

Where rain-water remains evident in the sole of a spouting or gutter, and does not evaporate with the sun or wind within three days, it is considered permanent ponding and any warranty for AZ coated spouting or gutters will be voided.

## 5.6 Valley Gutters

Valley gutters are installed on roofs with a pitch of less than 12° and are fully supported, but they should not be positively fixed, except at the head, because that will inhibit expansion and can produce noise. For this reason, the valley sole or upstand should not be returned or fixed under the roof cladding but should be terminated with a weather hook.

**Valley gutters must be fixed at the head to avoid creep, but must not be through fastened to the roof cladding. Valley gutters must discharge into a rainwater head, sump or eaves gutter, which must have an adjacent downpipe within 2 m of the valley discharge if the total catchment area serviced by the downpipe exceeds 50 m².**

**Valley gutters must be designed for the greatest rainfall likely in the area in a 50-year return period (ARI). The valley capacity must be able to discharge the total roof catchment area above the valley plus half the area of any dormer. See 9.9 Dormer Junctions.**

**A valley gutter must not be used where the roof pitch is less than 8°, but an internal box gutter, complying with the design criteria outlined in 5.3.2 Capacity Calculations, can be used.**

The dimensions of a valley gutter complying with *5.6E Metal Tile Valley*are suitable for most domestic roofs, with a minimum depth of 50 mm at the centre of the valley. Where the catchment area is less than 50 m², the valley dimensions should be increased by recessing the valley boards into the rafters or rescessing them between the rafters, supported on dwangs. See 5.6D Recessed Valley.

When the roof pitch is between 8° and 12°, the capacity of the gutter should be similarly increased, and the minimum depth should be increased to 75 mm. Alternatively, expand the width to increase the valley capacity by up to 50%.

Do not compromise the design capacity of the eaves gutter by cutting down the back of the gutter at the valley. If the valley is below the top of the eaves gutter, the gutter should be lowered at the discharge point, or the valley should be 'sprung' to this level.

If downpipes discharge into the catchment area served by a valley gutter the total catchment should not exceed the capacity of the valley.

Where the roof pitch is more than 35°, it is best practice to provide a central baffle, which can also act as an expansion joint. See 5.6D Recessed Valley.

When the roof pitch is 8° – 12° the valley should be made in one piece or the joints sealed.

The valley pitch will always be less than the roof pitch by a calculated value, eg where the roof pitch is 12° the valley pitch is 8.5°. See 9 External Moisture Penetrations.

To find the valley pitch when the roof pitch is known, and the valley is at 45° to the rafter:

- Find the tangent of the roof pitch. See *18.2 Roof Pitch Tangent.*
- Divide the tangent by 1.414(√ 2)
- Find the pitch.

## 5.6A Example

| | | |
|---|---|---|
| Roof Pitch 20° | =tangent | =0.364 |
| Valley Pitch | =0.364 | |
| | ÷ | 1.414(√ 2) |
| | =14.5° | |
| **New Valley Pitch** | =Valley Angle | |

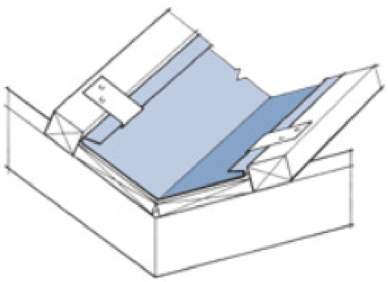
The total clearance between the sheeting on either side should be 80 mm, enough to allow a tennis ball to pass freely. The valley should be free to expand, but should be positively fixed at the head to avoid creep caused by expansion or by snow on steep roof slopes.

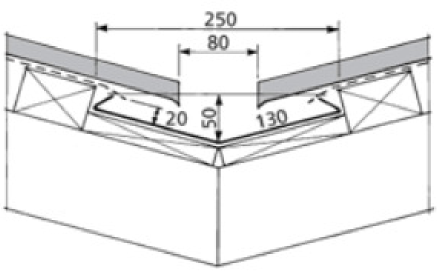
Valleys should not have a "wing" or return under the cladding which would be penetrated by any fixing, inhibiting free movement and causing noise. The sides of the valley should have an upstand, a weather hook, or should be folded as shown in 5.6B Hook Valley to 5.6E Metal Tile Valley. The hook should extend full height to the underside of the roof cladding.

There are alternative means of securing the valley gutter to the substrate. A simple clip system allows for movement and security. A compatible washered nail or screw is a suitable alternative, but a bent nail can cause damage to the metal cladding and is not durable. *See 5.6B Hook Valley*.

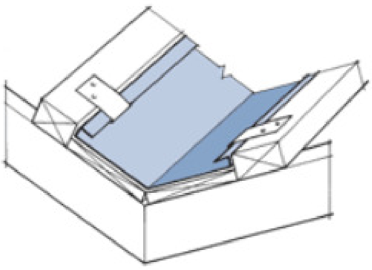
Alternative valley designs with the valley boards are on top of the rafter (5.6B Hook Valley), or cut into the rafter ( 5.6D Recessed Valley) are acceptable. Where they are cut into the jack rafter, the rafter depth should be increased, or the valley board cut between the rafters.

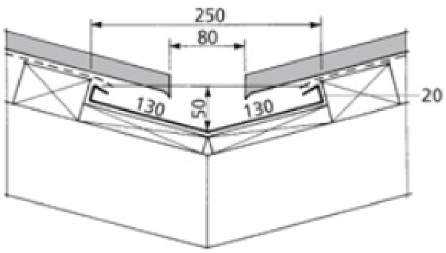
## 5.6B Hook Valley



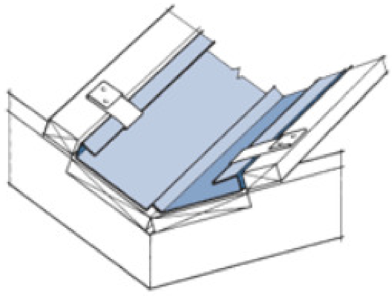


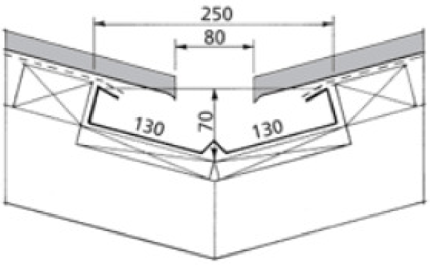

## 5.6C Standard Valley



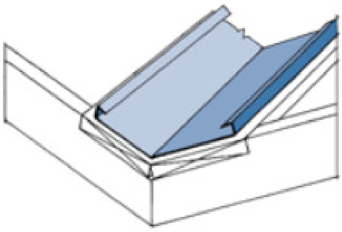


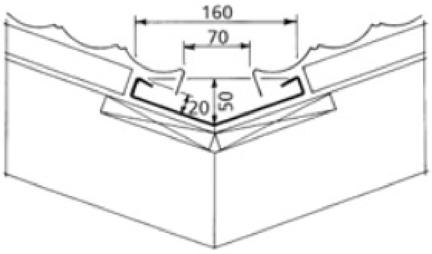
## 5.6D Recessed Valley






## 5.6E Metal Tile Valley






## 5.6.1 Valley Catchment

The capacity of a valley gutter is determined differently to standard gutters, which are flat or very near to flat. A valley is a gutter at the internal intersection of two sloping planes of roof cladding, where the roof pitch is more than 8°.

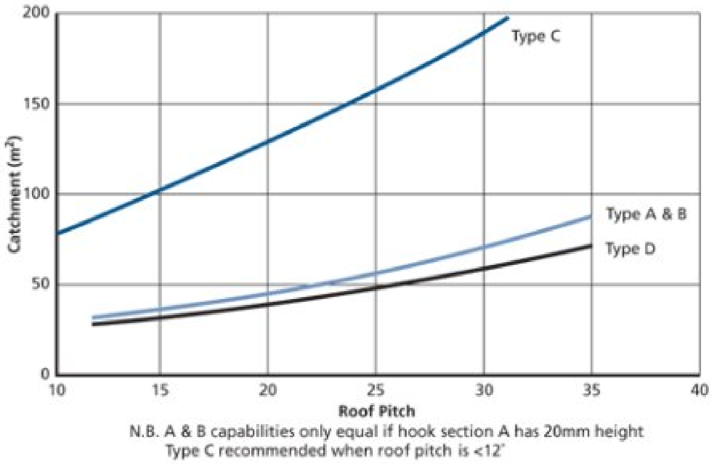
Because the minimum slope of a valley is more than 5.5°, the discharge rate is greater than that of a flat gutter. Roof pitch increases the rate of flow, and catchment area increases proportionately.

Research by Martin & Tilley, from CSIRO Australia, has been used to show the increase in 5.6.1A Valley Catchment Capabilities.

With the pitch of the roof known, the maximum catchment is determined from the graph.

5.6.1A Valley Catchment Capabilities has been calculated by allowing for 10 mm freeboard and roof cladding interference.

## 5.6.1A Valley Catchment Capabilities




## 5.6.2 Bifurcated Valleys

5.7.2A Oblique Gable Roofs with Different Widths shows the detail which is needed when placing a gable roof at an oblique angle to two other gables, but at a different width. Because there are two gable roofs at 90°, the catchment area increases and water should be channelled away from this vulnerable area.

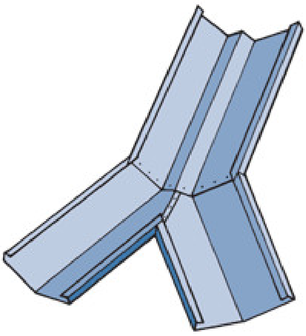
*5.6.2A Diverting Bifurcated Valley shows water being diverted away from this point and 5.6.2B Bifurcated Valley (Baffle Details) shows a bifurcated vally with baffle details.*

*The NZMRM COP emphasises that silicone sealant should not be used as the primary defence against water ingress. The design principle is to use a diverter which channels the water away from the line of flow using vertical overlapping flashing design. The maximum recommended catchment area for a bifurcated valley is 10m².*

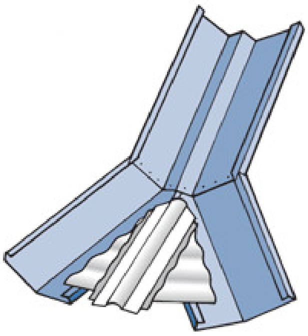
*Although 5.5.4 Internal Gutters advises not to change direction within an internal gutter, bifurcated valleys offer three differences.*

- *An internal gutter is normally laid flat, whereas 5.6 Valley Gutters requires a minimum roof pitch of 8°.*
- *The deviation from a straight line is only 22.5°, which is not regarded as a sharp change in direction.*
- *At the confluence, the catchment area is small and measured only in fractions of a square meter.*

## 5.6.2A Diverting Bifurcated Valley



## 5.6.2B Bifurcated Valley (Baffle Details)



## 5.7 Downpipes

Water collected by the gutters is transported to the storm-water disposal system via downpipes, and 5.3.2.1B Downpipe Size details the size of downpipes required for both external and internal gutters.

*Greater carrying capacity for downpipes can result from the head obtained by the use of sumps and rainwater heads.*

**The cross-sectional area of external downpipes must be half the cross-sectional area of the external gutter.**

**All internal downpipes must be sealed to internal sumps by a compression ring, or similar fitting, and must have access for cleaning at the base, where they are connected directly to the drain. To comply with the 50-year durability requirement of the NZBC, all hidden downpipes must be seamless and must be able to withstand a water test with an applied head of 1.5 m of water without leakage.**

**Internal downpipes that are easily replaced require a 15-year durability.**

**Where vertical downpipes are sealed to the drain internally, they must be designed with a minimum of half the cross-sectional area of the internal gutter.**

**The exterior junction or manhole must be vented to enable free discharge to the ground if the drain is blocked.**

Major internal building and consequential damage have been caused by failure to comply with these requirements rather than, as often assumed, because of inadequate design capacity of the roof drainage system. See 5.8.2 Outlets and Overflows.

Horizontal drains are not designed for the maximum rainfall that is required for gutters, and it is likely that their capacity will be exceeded during the life of the building.

To avoid any water back-up if the drain capacity is overloaded or obstructed, an air break should be provided for all downpipes to ensure that drain water does not back up the downpipe.

Ground outlets should be built up to avoid debris and surface water entering the drain.

**All exterior downpipes must discharge freely over a grated gully trap or into an oversize pipe which must be a minimum of 50 mm above the adjacent ground level.**

**Sealed water systems such as siphonic tank systems must have an overflow capacity of 200 mm/hour.**

**Downpipes fixed at an included angle of less than 105°, must have a cross-sectional area equal to that of the gutter.**

**Downpipes must be compatible with the roof and gutter material and must comply with the 15-year durability requirement of the NZBC.**

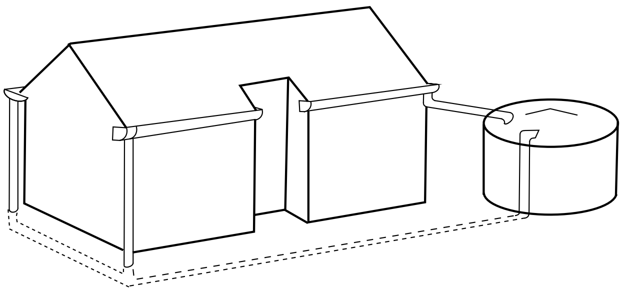
Galvanised steel downpipes should not be used to discharge rainwater from AZ coated or painted roof cladding.

When using galvanised rain-water goods with other materials, inert catchment corrosion should get special attention. (see section 2.6).

Horizontally run PVC downpipes should have a greater provision for expansion than metal, because they absorb heat, particularly if they are painted a dark colour. They should have a maximum length of 9 m before discharging into a rainwater head that will act as an overflow. PVC downpipes and spouting are also prone to damage by hail.

*When rain-water is collected into a water tank, there is often not enough distance to obtain adequate fall for one downpipe outlet. In such cases, or whenever the roof design pre-empts a continuous spouting to the tank, it is possible to have several sealed PVC downpipes–some of which can run underground to discharge into the tank. As these will remain full, it is necessary for the spouting outlet to be a rain-water head to avoid flooding.*

### 5.7A Collecting Rainwater



## 5.7.1 Downpipe Spreaders

**All downpipes that discharge onto a lower roof must have a spreader to ensure wide distribution of the water. Spreaders must not discharge directly over fasteners or at a lap and must have holes equalling twice the area of the downpipe.**

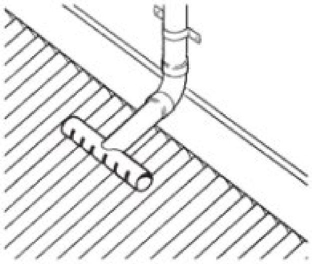
**Maximum catchment area above and downpipe size discharge onto a lower roof must be:**

- **60 m² and 63 mm for corrugate and symmetrical trapezoidal profiles;**
- **80 m² and 75 mm for asymmetrical trapezoidal profiles; and**
- **100 mm downpipes must not be drained onto a lower roof.**

**Copper spouting and downpipes must not drain onto a metal roof or wall cladding unless the cladding is also copper.**

A spreader should be used over several pans, but it is only suitable to distribute a limited amount of water before the pan capacity is exceeded. Large downpipes could overflow the profile if the downpipe is discharging at maximum capacity and, therefore, it is better practice for all downpipes to be continued separately to the drain at ground level.

### 5.7.1A



## 5.8 Sumps

The discharge capacity of a gutter increases with the depth of water over the outlet, and the best way to increase the head is to discharge the open end of the gutter into a sump. Swirl at the outlet will reduce its performance, so the positioning of the outlet is important.

**Sumps must have a grating or leaf-guard, have a flat base and must project above the calculated level of flow.**

**Overflows must provide a conspicuous warning that maintenance is required and must discharge clear of the building. Sumps must be the same width as the gutter and have a depth of 300 mm. Internal sumps must have an overflow as shown in 5.8B Internal Sump with Overt Overflow, otherwise they will act as an overflow and cause damage to the inside of the building. Outlets must be placed at a distance less than or equal to the outlet diameter from the nearest vertical side of the sump.**

**Sumps must have a grating or leaf-guard, but must not be placed directly in the outlet. The grating must have a flat base and not be tapered. See 5.8C Sump Leaf Guard.**

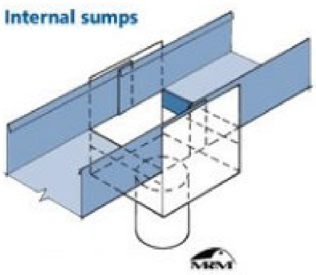
The overflow from an internal gutter can be an unsealed joint at ground level between the downpipe and the drain. See 5.8.2 Outlets and Overflows.

Gratings can cause sump blockage and can reduce the outlet capacity.

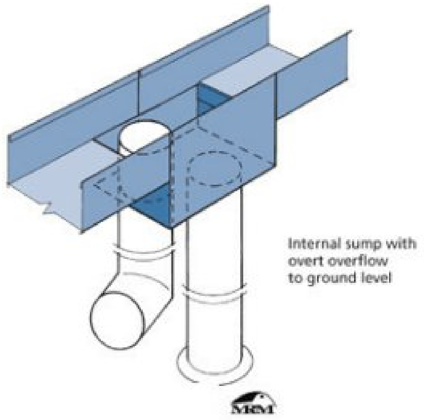
Gratings or guards should be designed so that any debris will float, and hail or obstructions such as a ball will not wedge and block the guard. Gratings or guards should be cleared of accumulated debris regularly during normal maintenance.

An internal sump should have a guard that prevents debris from blocking the outlet. An aluminium expanded metal, removable loose fitting box can be fitted as shown in 5.8C Sump Leaf Guard a minimum of 40 mm below the sole of the gutter. Because the top is flat, it is unlikely that the entire surface area of the outlet can become blocked as is the case with balloon type guards.

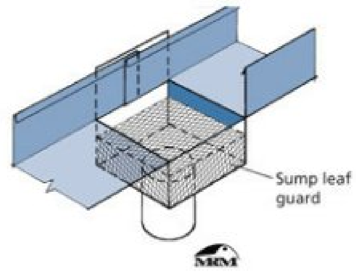
### 5.8A Internal Sump



## 5.8B Internal Sump with Overt Overflow



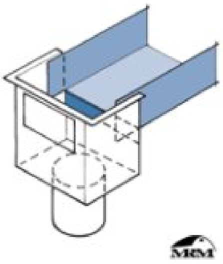

## 5.8C Sump Leaf Guard




## 5.8.1 Rainwater Heads

Rainwater heads should be placed on the outside of the building to ensure that the gutter will not overflow. Both rainwater heads and sumps can reduce turbulence and provide a head of water to maximise downpipe flow.

## 5.8.1A Rainwater Heads



## 5.8.2 Outlets and Overflows

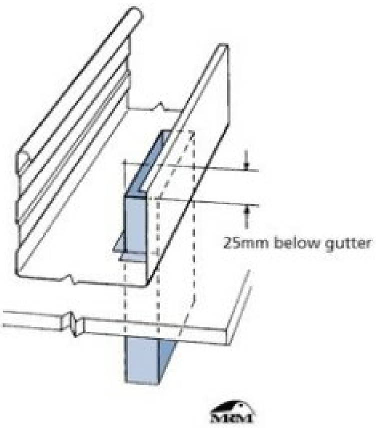
The type of outlet affects the flow rate of water from a gutter. Weir outlets are recommended as the best way to ensure positive flow from gutters or spouting with limited fall; they also provide an automatic overflow, because the spouting or gutter is not sealed to the downpipe or rainwater head.

**The overflow opening of a rainwater head from an external gutter must have a cross-sectional area equal to that of the downpipe. The bottom of the overflow must be no higher than 25 mm below the bottom of the spouting.**

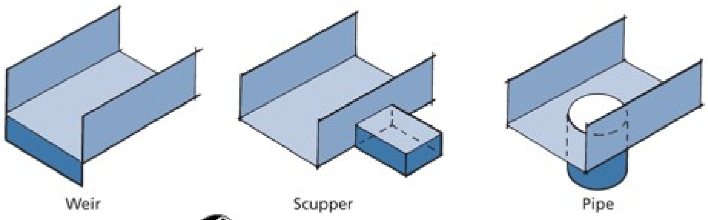
**The overflow opening of a rainwater head from an internal gutter must have a cross-sectional area equal to that of the gutter, and the overflow weir must be 25 mm below the sole of the gutter. See** 5.8.1A Rainwater Heads.

**Overflows must provide a conspicuous warning that maintenance is required and must discharge clear of the building.**

## 5.8.2A Outlet and Overflow Types



## 5.8.2B Weir, Scupper and Downpipe




Drawing 8.6.2.C.

Where the position of an outlet of a parapet wall gutter is on an outside wall, any scupper overflow cut through the wall should discharge on to the same property.

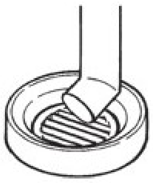
For parapet wall gutters, where the position of an outlet is within the building, a minimum of two downpipe outlets from the sump should be used, joined separately to the downpipe beyond any offset. Alternatively, a separate overflow pipe of equal capacity to the outlet can be used with the top 25 mm below the sole of the gutter and run to discharge onto the ground. See 5.8.2A Outlet and Overflow Types.

Downpipes that discharge over a gully trap or ground sump provide an automatic overflow if the drain becomes blocked. See 5.8.2C Gully Trap.

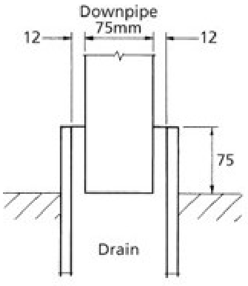
Using an oversize drain without any sealing can also act as an overflow by providing an air break. See 5.8.2D Air Break.

Spouting can be made fail-safe for overflowing by providing a rainwater head as shown in 5.8.2A Outlet and Overflow Types.

## 5.8.2C Gully Trap



## 5.8.2D Air Break



# 6 External Moisture Overview

The primary function of a roof is to shed external moisture. The Code of Practice deals with External Moisture in four sections, allowing for more detailed discussion. The solutions in the COP relate to all buildings and are not limited to buildings within the scope of NZS 3604.

Included in the COP under External Moisture:

6 External Moisture Overview provides an extract from NZBC E2 External Moisture. It highlights the Objectives, Functional Requirements, Performance Requirements, and Limits of the NZBC Clause E2. The second half highlights the scope and extent of Acceptable Solution E2/AS1.

7 External Moisture Roofing discusses the external moisture requirements and strategies for dealing with external moisture where it concerns metal roof and wall cladding.

8 External Moisture Flashings discusses strategies of managing external moisture with a specific focus on flashings.

9 External Moisture Penetrations focusses specifically on managing external moisture and preventing leaks around penetrations.

## 6.1 NZBC Clause E2 External Moisture (Extract)

### 6.1.1 E2 Objective

*The objective of this provision is to safeguard people from illness or injury which could result from external moisture entering the building.*

### 6.1.2 E2 Functional Requirement

*Buildings should be constructed to provide adequate resistance to penetration by, and the accumulation of, moisture from the outside.*

### 6.1.3 E2 Performance Requirements

1. *Roofs shall shed precipitated moisture and snow.*
2. *Roofs and external walls shall prevent the penetration of water that will cause dampness or damage to the building elements.*

*Other performance requirements quoted relate to transmission of ground moisture, areas below suspended floors, condensation in concealed cavities, and construction moisture.*

## 6.2
## Acceptable Solution NZBC E2/AS1

### *Scope*

*This Acceptable Solution covers the weathertightness of the building envelope.*

### *Construction Included*

*All New Zealand buildings within the scope of NZS3604.*

### *Construction Excluded*

*Outbuildings such as garages and other unlined structures are excluded from the scope of NZS 3604.*

## 6.2.1
## Compliance

*The provisions of E2/AS1 are designed to be adequate to protect lined, primarily residential structures, where water ingress can cause expensive damage to structure and contents and cause ill health to the inhabitants.*

*Outbuildings are outside the scope of E2/AS1, as the acceptable degree of weathertightness of outbuildings is often less than that of a dwelling. Awnings and covered ways are excluded because they are outside the building element and designed to be exposed to the weather.*

*"Other unlined structures" are also excluded. In many cases, a less robust criterion can be applied to unlined structures because:*

- *leaks are more readily identified and can be rectified before they cause lasting damage,*
- *the value or vulnerability of the contents may be less than that of a dwelling,*
- *the buildings are generally better ventilated,*
- *the building itself may be only sporadically populated,*
- *the structure is accessible for inspection and maintenance.*

*Often the solutions contained in E2/AS1 are applied equally stringently across all non-residential unlined buildings. In many cases, this is an overly strict requirement and a more pragmatic approach more logical. Designers and compliance officers should consider the building's vulnerability to damage from water ingress, allowing for factors such as accessibility for maintenance and intended end use when considering compliance requirements.*

# 6.3 Related Topics

NZBC E2 – External Moisture is primarily focussed on a buildings' external envelope being able to resist weather infiltration.

Acceptable Solution E2/AS1 also has some information on gutter sizing and durability, but these are also covered in E1 – Surface Water and B2 – Durability.

E2/AS1 also has some prescriptive solutions for structure regarding roofing spans which are omitted from B1 - Structure.

For clarity, this Code of Practice deals with the following topics discretely:

- Resistance to loads in 3 Structure.
- Durability covered in 4 Durability
- Gutter design covered in 5 Roof Drainage .
- NZBC E2 Compliance requirements in 6 External Moisture Overview.
- Managing water ingress of metal roof and wall cladding in 7 External Moisture Roofing.
- Managing water ingress through flashings in 8 External Moisture Flashings.
- Managing weathertightness of penetrations in 9 External Moisture Penetrations.
- Managing Internal Moisture is covered in 10 Roof Ventilation .

# 7 External Moisture Roofing

This section should be read in conjunction with 6 External Moisture Overview.

## 7.1 Roof Pitch

The pitch is the angle between the horizontal and the roof line. It is also the relationship between the rise and the horizontal span of the roof. See 18.2 Roof Pitch Tangent for the tabulation of these values and a calculation tool.

### 7.1.1 Minimum Roof Cladding Pitch

#### 7.1.1A Minimum Recommended Pitch

| Profile | Rib Height | Minimum Pitch | Rise per metre of Span |
|---|---|---|---|
| Trapezoidal asymmetrical | 20 – 35 mm | 3° | 52 mm |
| Trapezoidal asymmetrical and symmetrical | 36 – 60 mm | 3° | 52 mm |
| Trapezoidal symmetrical | 20 – 35 mm | 4° | 70 mm |
| Secret-fix | >30 mm | 3° | 52 mm |
| secret-fix | <30 mm | 8° | 141 mm |
| Standing seam fully supported flat sheet metal | >30 mm | 3° | 52 mm |
| All other types of fully supported flat sheet metal | | 5° | 87 |
| Corrugated and other profiled sheeting | 16.5 – 20 mm | 8° | 141 mm |
| Corrugated and other profiled sheeting | 21 – 35 mm | 4° | 70 mm |
| Horizontally lapped metal tile | 25 mm upstand | 12° | 213 mm |

*Minimum pitches quoted in this table refer to roof cladding pitch and not the building design roof pitch.*

Buildings designed with widely spaced purlins and widely spaced portal frames may require an increased design pitch to comply with the minimum recommended as-laid pitches.

Low pitched roofs require greater attention to flashing details. The ability of side laps or end laps to withstand water penetration also becomes more critical at low pitches, but the good design of flashings can ensure weathertightness in extreme conditions.

*Water backup against vertical faces caused by high velocity, localised wind eddies, especially inside parapets and at the bottom edge of walls, are all vulnerable details. Pressure equalisation-designs and wind baffles are more effective in preventing water ingress than increasing the flashing cover width.*

#### 7.1.1B Exceptions to the Minimum Recommended Roof Cladding Pitch requirements:

- curved roofs, where by design the minimum pitch at the crest is always less than the prescribed minimum pitch. In these cases, the pitch at the eaves must comply with the profile's minimum pitch, and the pitch at the upper end of a terminated arc must be a minimum of 3°. *(See 15.1 Curved Roofs).*
- The back curbs of penetration flashings where the minimum pitch is 1.5°. (See 9 External Moisture Penetrations)

### 7.1.2

## Runoff

Runoff is the ability of the roof cladding to discharge maximum rainfall without water penetrating through side laps, end laps or flashings and depends on rainfall, the catchment area, the roof pitch, and the profile geometry.

The pitch determines the rate of flow. Steep slopes shed water faster than shallow slopes. However, at minimum falls, with a maximum rainfall intensity of 100 mm/hour, trapezoidal rib profiles with a height greater than 26 mm can have a maximum run of at least 40 m, and trapezoidal rib profiles with a rib height 20-25 mm can have a maximum run of at least 30 m.

The roof gutter capacity calculator in 5 Roof Drainage can calculate capacities for any known profile, rainfall and pitch, by treating the pan width and rib height as a gutter and the rib to rib dimension plus any discharge from adjacent surfaces as the catchment. When the sheeting length exceeds the above limitations, the capacities should be checked.

# 7.2 Fastening Roofing

All fastenings that pierce the sheeting should be provided with adequate sealing washers to prevent leakage. Sealing washers should be made from Ethylene Propylene Diene Monomer (EPDM).

Fastenings should be tightened only enough to form a weatherproof seal without damaging the sealing washer or deforming the sheet profile. Deformed sheeting will cause water to pond around the seal.

Swarf should be removed from under the sealing washer as it will not only cause staining but also interfere with the seal.

## 7.3
## Thermal Expansion And Contraction

All metal cladding and flashings are subject to expansion and contraction caused by changes in temperature, and their design should allow for this movement. The energy produced should be absorbed without damage to the cladding, fixings or structure. The recommendations in this section are specific to preventing damage and leaks through thermal movement. Thermal movement can also cause disturbing noise levels in dwellings with shorter member lengths than those recommended in this section. (See 12.1 Roof Noise.)

The ribs of metal trapezoidal or corrugated roof and wall cladding absorb expansion across the width of the sheets, but special provisions are needed over the sheets' length.

Much of the longitudinal expansion is taken up by the bowing of the sheet between fastened supports. The extent to which this happens depends on the profile strength and support spacings.

Failure by thermal expansion normally results in shearing of the fastener. Fasteners into lightweight steel purlins up to 3 mm in thickness are less vulnerable as they tend to rotate rather than be subjected to repeated bending resulting in fatigue failure. Fasteners into hot rolled steel sections or timber are far more vulnerable to this mode of failure and in all run lengths over 20 metres provision for expansion must be made when fastening into such supports.

Where overlapping sheets are fastened through the ends, they must be considered as one length to calculate thermal movement. Unfastened end laps are not recommended.

Wall cladding does not require the same provisions as roof cladding, because of solar radiation angle.

Oversized holes and washers give some room for expansion and contraction, but it is not enough to allow movement without stress or distortion over long spans. In such cases, a step joint should be used. (See 8.4.4.3B Stepped Roof Flashing)

### 7.3.1
### Temperature Range

*Ranges of temperature likely to be experienced in NZ by different steel cladding are:*

#### 7.3.1A Steel Cladding Temperature Ranges

| | | Max/Min Roof Temp °C | No Wind |
|---|---|---|---|
| *Insulated* | *Light colour* | *+60° -15°* | *= 75°* |
| *Insulated* | *Dark colour* | *+80° -15°* | *= 95°* |
| *Uninsulated* | *Light colour* | *+50° -10°* | *= 60°* |
| *Uninsulated* | *Dark colour* | *+65° -10°* | *= 75°* |

*Aluminium and zinc, which have twice the expansion rate of steel, do not necessarily expand to this degree because of the different characteristics of mass, emittance, and radiance which affects their temperature range. Copper expands one and a half times as much as steel, and stainless steel can expand up to 1.5 times as much as steel depending on composition.*

*The theoretical expansion of steel roof cladding in mm is 12 x temperature change x length in metres/1000.*

*Steel expansion rates can be calculated as follows:*

*Given a length (e.g., 30 m) and that the material (e.g., a light-coloured uninsulated roof) moves through a 60°C range (e.g., + 50°C -10°C), the theoretical increase in length is 12 x 60 x 30/1000 = 21.6 mm.*

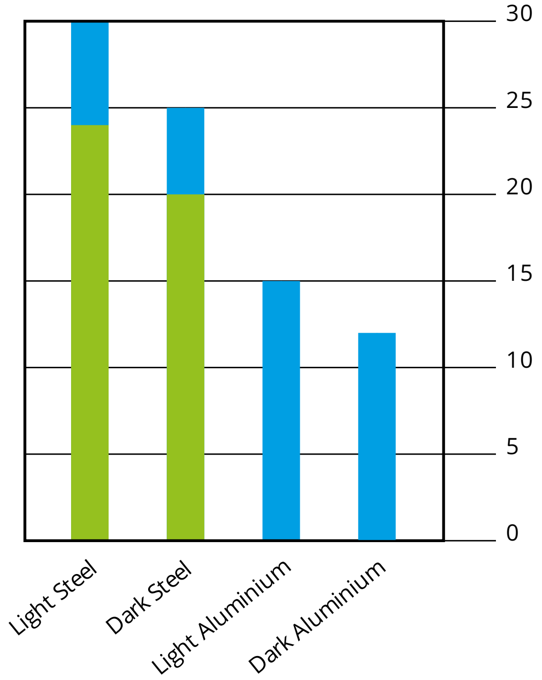
*This amount of movement of roof cladding and components does not have to be provided for in practice, because:*

- *The building also expands with the ambient temperature, although to a lesser degree.*
- *Fasteners into light gauge purlins will roll rather than bend. The purlin flange may also roll to a degree.*
- *The roof cladding bows between purlins when it is constrained. Sighting down a corrugated steel roof on a warm sunny day will show an undulating line compared to a straight line when the roof is cool. The forces created by expansion and contraction are self-levelling, i.e., each component moves under load until the resisting force is more than the expansion force.*
- *When a length of sheeting is solid fastened at the centre and unconstrained at either end, the movement is towards the ends of the sheeting; meaning the actual expansion or contraction movement is only half that of a full length of roof or wall cladding fastened at one end. Special design of the ridge or head barge flashing is required in these cases to allow free movement. Alternatively, sheets can be solidly fixed at the upper region, so all expansion takes place in the lower part of the sheet towards the eaves.*

## 7.3.2 Roof Cladding Expansion Provisions

The expansion of roof cladding depends on the materials, the constraints imposed by the fixing, the heat paths in the building and the actual temperature. The following graphics are indicative of favourable and unfavourable conditions for thermal expansion and suggest what these are. They show the lengths under both sets of conditions above which special provision needs to be made to accomodate thermal expansion.

## 7.3.2A Favourable Circumstances for Controlling Expansion

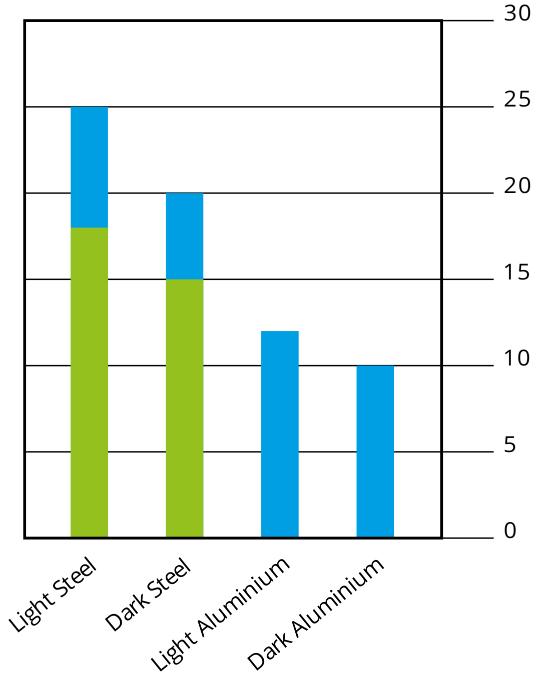



- Flexible light gauge steel purlins <3mm
- Light coloured roof cladding
- Purlin spacings greater than 1.5 m
- Crest Fixing
- Building not insulated
- Ventilated air space below roof cladding and underlay
- Low rib profile or corrugate

No special requirements

9mm oversized holes and load spreading washers

## 7.3.2B Unfavourable Circumstances for Controlling Expansion




- Purlins made out of hot rolled steel or thicker than 3 mm.
- Laminated timber purlins
- Purlin spacings of less than 1.5 m
- Pan Fixing
- Dark coloured roof cladding
- Skillion Roof
- Rigid profiles, e.g., high rib

No special requirements

9mm oversized holes and load spreading washers

**Notes:**

1. Where a roof requires oversize holes, only the portion of the roof outside of the recommendations require provision for expansion. Normally this takes place towards the eaves
2. These are guidelines only and special engineering of the roof, fixing or ventilation may allow greater spans to be used.
3. These diagrams refer only to roof cladding screwed through the top. Secret or clip fixed roofs can move more freely if installed correctly and allow for using greater run lengths.
4. The recommendations are based on preventing damage to the fasteners and are not a recommendation to prevent roof noise.

# 7.4 End Laps

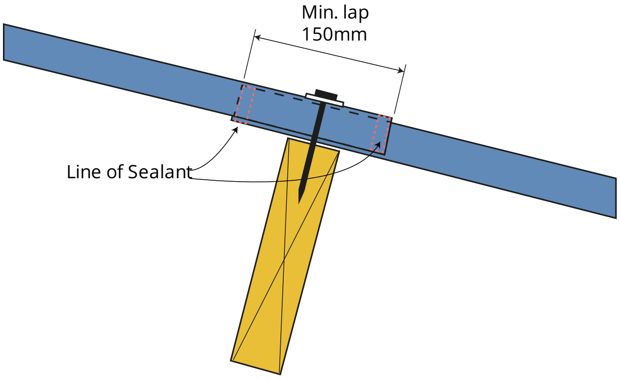
End laps should be avoided if possible when installing metal roof cladding as an incorrectly sealed end lap may entrap water and cause corrosion. When the sheets are too long to be transported or exceed the longest recommended length (see 7.3.2 Roof Cladding Expansion Provisions), the transverse or end lap joint can be avoided by using a waterfall step. (See 8.4.4.3A Step Apron Details)

When long lengths outside the capacity of available transport are required, secret-fixed roof cladding can be supplied by using an onsite roll-forming machine.

Where end laps are unavoidable, a sealed joint should be made using sealant at both ends of the lap. The upper seal is critical as condensation entering the upper side of the lap from underneath can cause rapid corrosion. Rivets are used to fix the sheets together and should not be fastened to the purlin. The sheets are fixed to the purlin using screw fixings.

The two lengths should be regarded as one length for expansion provisions.

## 7.4A Sealed End Lap



# 8 External Moisture Flashings

*This section should be read in conjunction with 6 External Moisture Overview and 9 External Moisture Penetrations.*

The purpose of a flashing is to divert water away from any point of entry and to make a building weatherproof.

Flashings are not only required to weather the many junctions on a roof or wall structure but are often a highly visible part of the roof and wall cladding design. Therefore, they perform an important role in the aesthetic appearance of the building.

It takes longer to make and install flashings than fixing roof or wall cladding, so designers should be aware of the cost effects of design complexity.

## 8.1 Flashing Materials

Exposed flashings are typically manufactured using the same base metal material as used for the roof and wall cladding. If flashings are required to match the colour of the profiled cladding, it is necessary for the pre-painted flat sheet or coil to be made by the same manufacturer, using the same process. When it is not possible, or if different materials are intended or specified, the alternative materials should be compatible considering both contact and runoff. (See 4.10.3 Compatibility Table)

All flashings must be fabricated from a ductile material and designed for lateral strength by folding, stiffening, or ribbing on external edges, with a maximum unstiffened width of 300 mm.

Vertical faces of flashings such as barges and fascia can exhibit oil canning. This can be minimised by using heavier gauge material, by forming stiffeners, or by providing clip fastened attachment systems which allow for thermal movement. In critical visual areas, the COP recommends a maximum unstiffened depth of 200 mm on the vertical face.

**Metal flashings must have a bend radius complying with the minimum radii prescribed in 4.11.8 Microcracking.**

**The minimum thickness for metal flashings must be:**

- **Coated steel — 0.55 mm,**
- **Aluminium — 0.70 mm,**
- **Copper — 0.60 mm,**
- **Zinc — 0.70 mm,**
- **Stainless steel — 0.45 mm.**

Proprietary EPDM penetration flashings are detailed in 9.6 Boot Flashings.

### 8.1.1 Flashing Durability

Where a flashing is hidden or is otherwise difficult to access for maintenance or replacement, or it requires cladding to be removed to replace the flashing, it must have durability for the life of the building or not less than 50 years. All flashings should be made from materials with a durability expectation not less than that of the cladding.

In some corrosive environments, stainless steel or non-ferrous metals should be used for flashings. All metals must be checked for compatibility with the roof material. (See 4.10 Compatibility and 4.10.3B Interactive Material Compatibility Tool)

# 8.2 Flashing Design

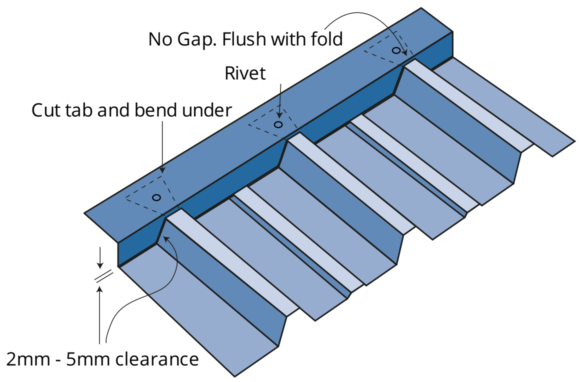
Transverse flashings run across the roof slope at right angles to the ribs of the roof and longitudinal flashings run down the roof slope.

Ingress of rain into the roof or wall cavity via the flashings can be caused by the pressure differential between the air outside and that inside the roof or wall cavity. The pressure differential caused by wind gusting fluctuates greatly, so a gap should be created behind the outer edge of a flashing to provide a pressure cushion. Longitudinal flashings are best designed with a pressure equalisation gap to balance varying pressures and prevent capillary action. (See 4.11.6 Capillary Action.)

The preferred maximum production length of flashing is 6–8 m, depending on profile strength. As any sealed lap secured by rivets or screws effectively becomes one length, provide expansion joints where required. Flashings are similarly restricted in length as roof and wall cladding sheets and are subject to the same requirements and expansion provisions. (See 7.3.2 Roof Cladding Expansion Provisions.) Inadequate provision for flashing expansion can also cause roof noise

Avoid wet contact between the edges of flashings and concrete, plaster or butyl rubber (See 4.10 Compatibility.) When notched flashings are used, the cut edge must not touch the pan, as that can cause corrosion from abrasion.

## 8.2A Notched Flashing



## 8.3
## Flashing Cover

The weathertightness of a flashing is determined by the flashing cover, not the flashing dimension.

**The minimum dimension for flashing cover (C) over profiled metal roof and wall cladding must correlate with 8.3A Minimum Dimension 'C' Flashing Cover.**

**There are two categories of exposure or pitch that determine the flashing cover width. These categories apply to buildings within the scope of NZS 3604 only.**

Category A:

- **Low, Medium or High Wind Zones, and**
- **where the pitch is no less than 10°.**

Category B:

- **Very High and Extra High Wind Zones, or**
- **where the pitch is less than 10°.**

**NOTE:**

This chart is relevant to trapezoidal profiles with a height of 25 – 34 mm and standard corrugate. Barge and apron flashings over profiles with a minimum 35 mm may have one rib overlap.

## 8.3A Minimum Dimension 'C' Flashing Cover

| TYPE | Direction | Category A | Category B | Drawing |
|---|---|---|---|---|
| **RIDGE** | Transverse over sheeting | 130 mm | 200 mm | 8.3B Ridge Flashing |
| **BARGE** | Longitudinal trapezoidal & tray | one rib | one rib, two ribs (<20 mm) | |
| | Longitudinal corrugate | 2 corrugations | 3 corrugations | |
| | Vertically down face (smooth) | 50 mm | 75 mm | |
| | Vertically down face (profiled) | 75 mm | 100 mm | |
| **APRON** | Transverse over sheeting | 150 mm | 200 mm | 8.3C Transverse Apron |
| | Longitudinal trapezoidal & tray | one rib | two ribs (<20 mm)* | |
| | Longitudinal corrugate | 2 corrugations | 3 corrugations | |
| | Vertically up face (smooth) | 50 mm+ hem or 75 mm | 75 mm + hem or 100 mm | 8.3C Transverse Apron |
| | Vertically up face (profiled) | 75 mm + hem or 100 mm | 100 mm + hem or 125 mm | 8.3C Transverse Apron |
| **PARAPET** | Vertically down face (smooth) | 50 mm | 75 mm | 8.3D Parapet Cap |
| | Vertically down face (profiled) | 75 mm | 100 mm | 8.3D Parapet Cap |

** Not to exceed 300mm.*

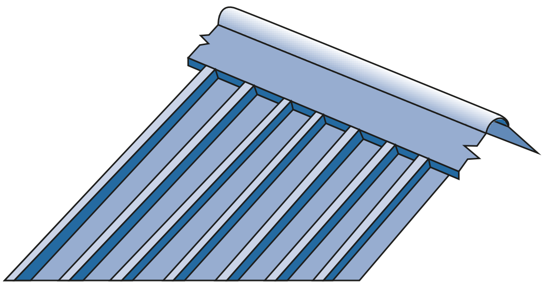
The end of wall cladding should have a minimum clearance of 25 mm from an apron flashing or another horizontal surface. Where vegetation is present, or debris may accumulate, greater clearances or regular maintenance is required to achieve optimum durability. (See 4 Durability)

The dressed soft edging or the downturn of a notched flashing acts as a baffle to wind and rain at the outside edge of a transverse flashing, as does the stop end of the cladding at the upper end. The void in between these two barriers acts as a pressure equalisation gap.

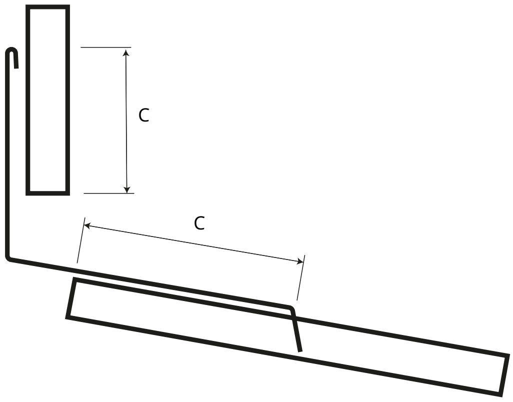
**Pull-up stop ends must be provided for all pitches in all wind zones**

In extreme circumstances, a profiled or notched closure can be used between these two baffles if required. When closures or filler blocks are used, they must be adhered to the profile or secured by the cladding fasteners to ensure they remain in position. Ventilation requirements must be considered when using profiled closures.

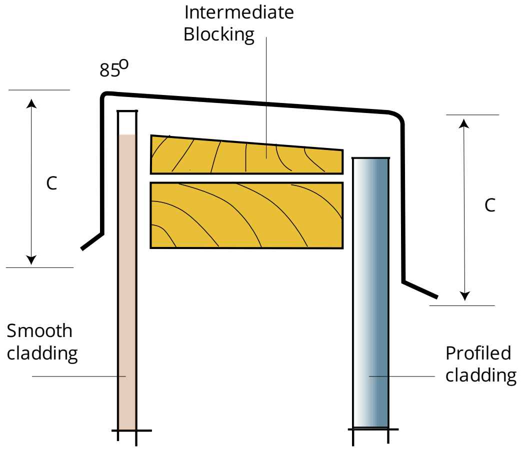
## 8.3B Ridge Flashing



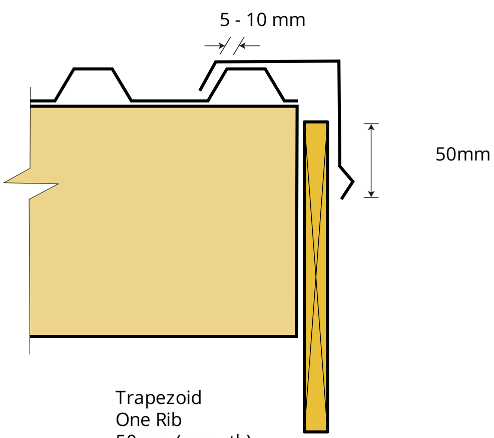
## 8.3C Transverse Apron




## 8.3D Parapet Cap

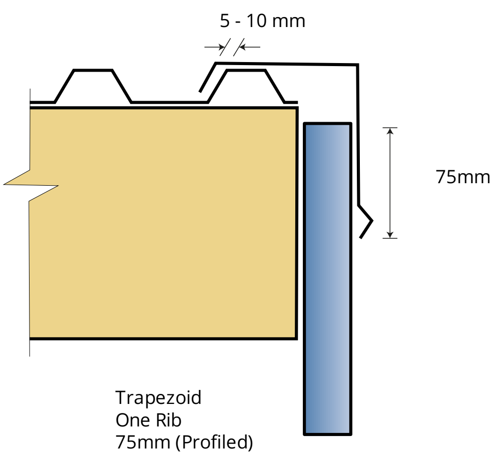


## 8.3E Barge Flashing Over One Trapezoidal Rib, Smooth Vertical Cladding

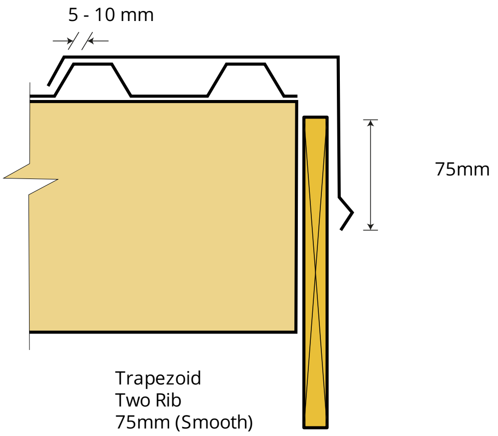



*Cover two ribs with low rib trapezoidal on residential when the pitch is less than 10° and the wind zone is very high or extremely high. The face edge of a barge flashing must be attached to the fascia or wall cladding with pierce fasteners or sliding clips*

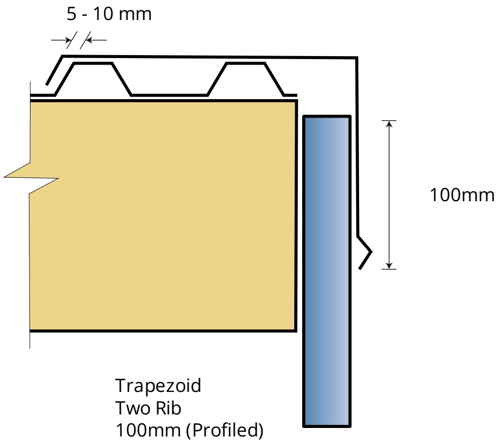
## 8.3F Barge Flashing over One Trapezoidal Rib, Profiled Vertical Cladding



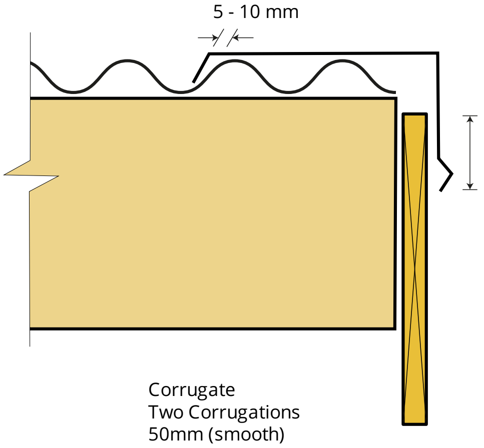
## 8.3G Barge Flashing over Two Trapezoidal Ribs, Smooth Vertical Cladding



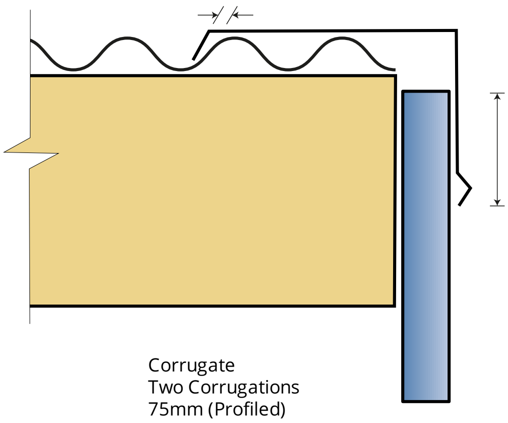

## 8.3H Barge Flashing over Two Trapezoidal Ribs, Profiled Vertical Cladding



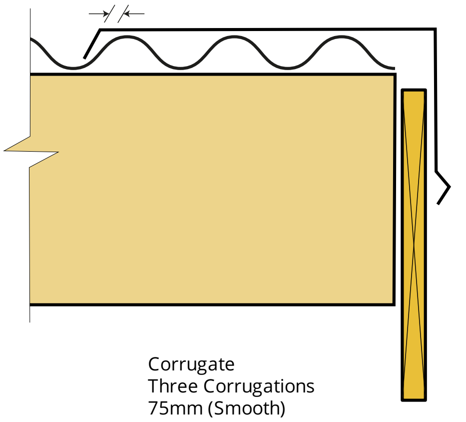
## 8.3I Barge flashing over Two Corrugations, Smooth Vertical Cladding



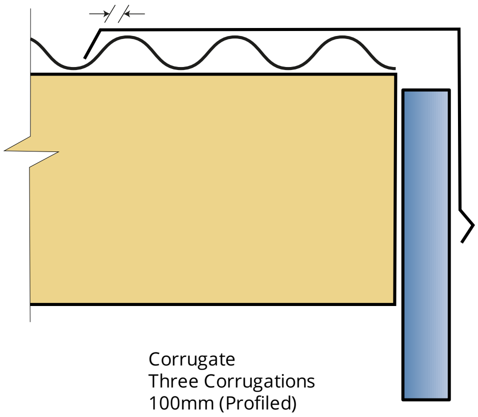

## 8.3J Barge Flashing over Two Corrugations, Profiled Vertical Cladding



## 8.3K Barge Flashing over Three Corrugations, Smooth Vertical Cladding




## 8.3L Barge Flashing over Three Corrugations, Profiled Cladding




## 8.3M Ridging and Other Transverse Flashings

A soft edge or notched flashing must be provided to transverse flashings. The positioning of the top purlin must be adjusted with the pitch and the ridge girth to ensure that primary fastening is provided between 15 mm and 50 mm from the leading edge of the flashing.

## 8.3N Apron Upstands

The upstand of an apron flashing varies depending on whether the upstand is hemmed or unhemmed, and the covering cladding is smooth or profiled. Profiled claddings require more coverage because they allow vertical air movement through the voids of the profile.

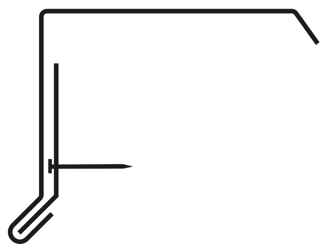
## 8.3.1 Flashing Laps

Laps in flashings should comply with the following criteria:

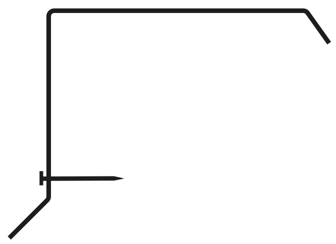
- Water must flow over a lap, not into it,
- a lap must not rely solely on sealant,
- sealed laps must be mechanically fixed at 50 mm centres, and
- end laps must be a minimum of 150 mm for unsealed laps and 100 mm for sealed laps.

## 8.3.2 Flashing Edges

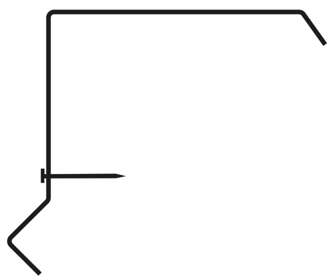
### 8.3.2A Hemmed Flashing



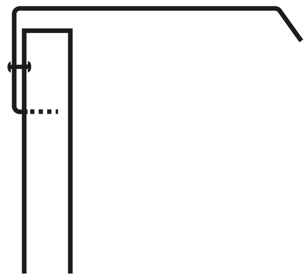
### 8.3.2B Kick-out Flashing



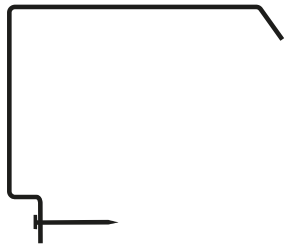
### 8.3.2C Bird's Beak Flashing



## 8.3.2D Notched Flashing Edge



## 8.3.2E Boxed Flashing



## 8.3.2F Kick-in Flashing

## 8.3.2G Flashing Hook

*Anti-capillary hems must be flattened parallel but not completely crushed.*

## 8.3.2H Flashing Hem

## 8.3.2I Flashing Crush Fold

## 8.4 Flashing Types

Different types of flashings include:

- *Ridge and Hip.*
- *Barge and Verge.*
- *Parapet Cappings.*
- *Apron.*
- *Valley.*
- *Curved.*

*See 9 External Moisture Penetrations for penetration flashings.*

### 8.4.1 Ridge And Hip

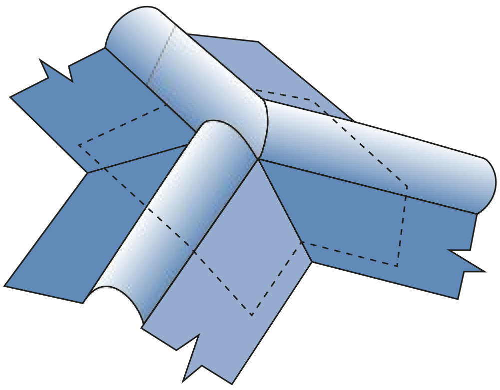
*Ridge and hip roll top flashings are roll-formed as a standard pitch flashing with a soft edge. When the angle of the flashing is not custom-made to suit the roof, it can result in visible distortion and stress around the fastening if used on pitches steeper than 35°.*

*Custom-made square top ridging is available for any pitch and width and is available in lengths of up to 8 m. The roll top or square top of a ridging helps accommodate expansion of the roof sheeting and strengthens the ridge.*

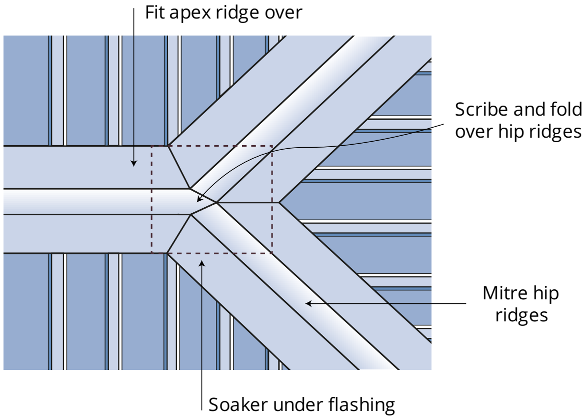
*A vee ridge is not able to support walking traffic and is vulnerable to buckling caused by point load and lateral or longitudinal thermal movement.*

*A soft-edged flashing can be used for corrugated and low rib trapezoidal profiles, and notched ridging can be used on all trapezoidal, trough or standing seam profiles.*

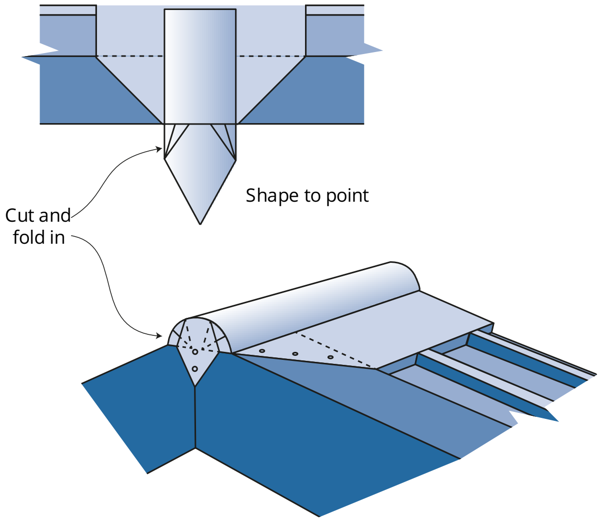
#### 8.4.1A Soaker Ridge Cap



## 8.4.1B Ridge-hip Intersection




## 8.4.1C Ridge End




The transition of the ridge and the apex of a hip requires skill to make a neat and weathertight finish and relies on sealant for prolonged weather tightness. An under-flashing such as soft aluminium, waterproof tape, or EPDM membrane is recommended as a secondary means of making this joint waterproof in conjunction with the ridge-hip intersection design. (See 8.4.1C Ridge End)

The gable end termination of roll ridging must be made vermin proof by cutting the ridging back 25 mm and closing it. (See 7.4.1.1C Roll-top End Cap )

As an alternative to continuous ridging on ribbed profiled sheets, use individual rib or ridge caps fitted to each rib after the ribs have been cut and the roof cladding bent over the ridge. Each cap should be accurately fitted and sealed. This method does not allow for free expansion at the ridge of long length roof cladding and restricts natural ventilation of the ceiling cavity. These caps rely on sealant to be made watertight and are only recommended for use at the apex of a roof and when there is sufficient ventilation.

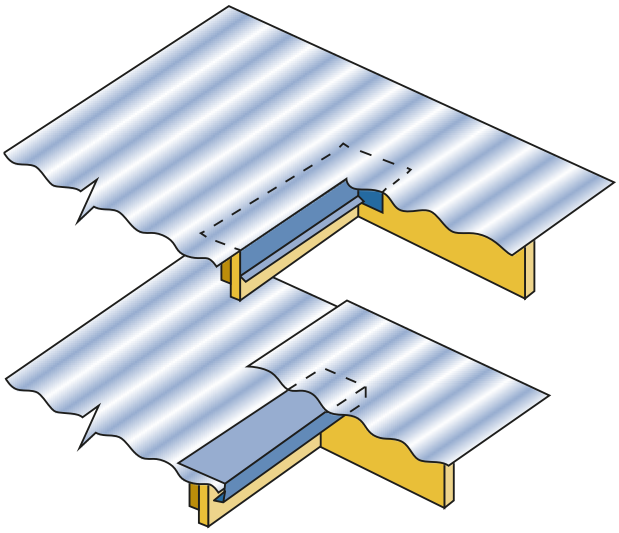
## 8.4.2 Barge And Verge

Barge or verge flashings assist in holding the roof cladding in place under high wind loads at the periphery.

Where barge flashings are omitted, the roof must be designed to withstand the upwards loads imposed on both surfaces of the roof cladding edges.

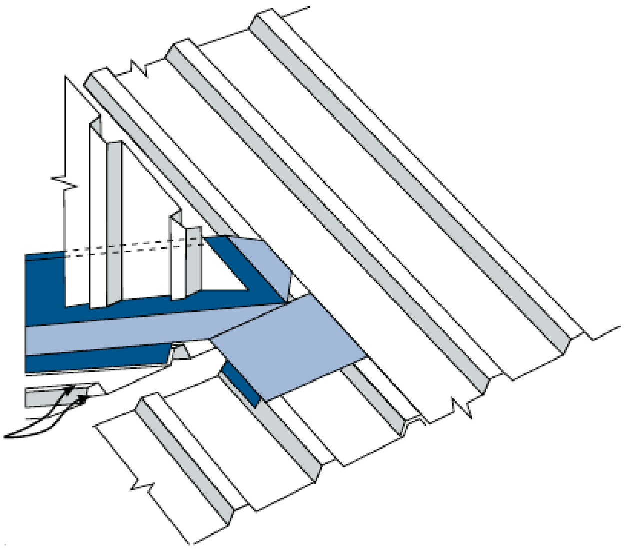
A transition flashing must be provided when the roof cladding weathers the barge at an internal angle.

### 8.4.2A Transition Flashings

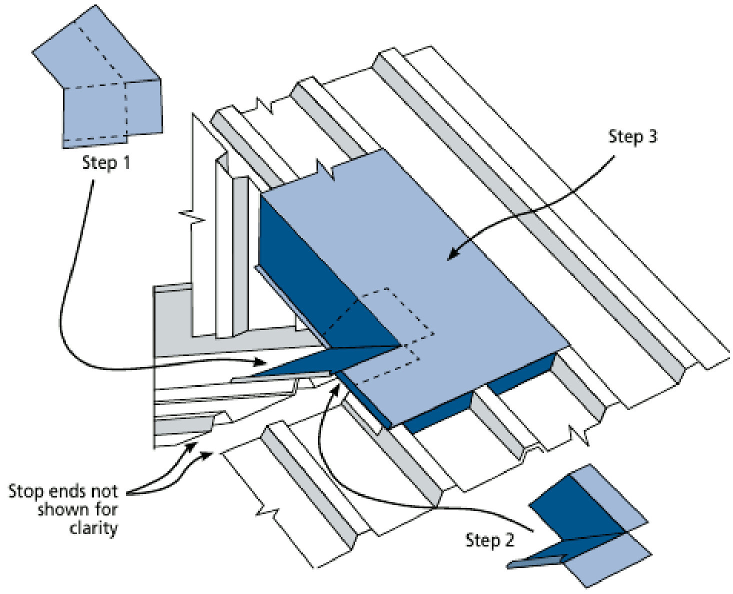


## 8.4.2.1 Ridge – barge Intersections

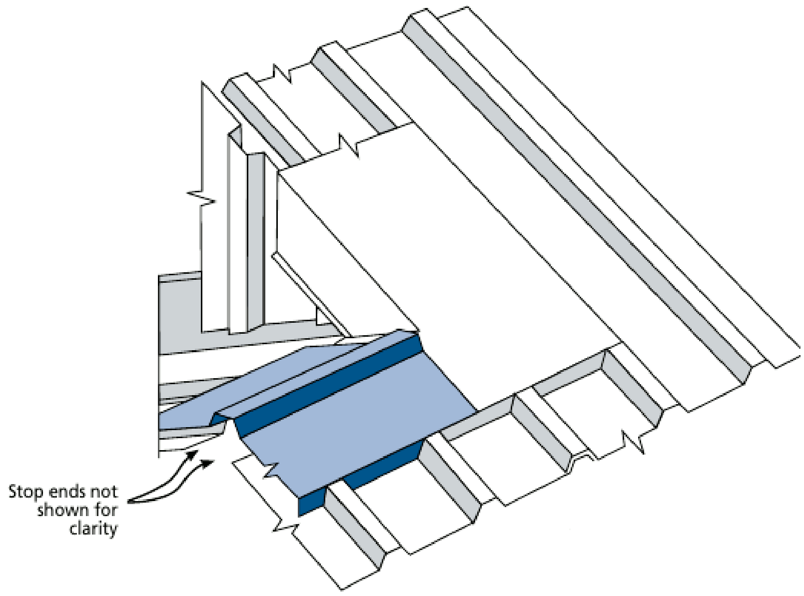
### 8.4.2.1A Shorter Gable meets Eave Overhang



## 8.4.2.1B Barge Flashing on an Internal Corner




## 8.4.2.1C Barge Flashing — Ridge Cap



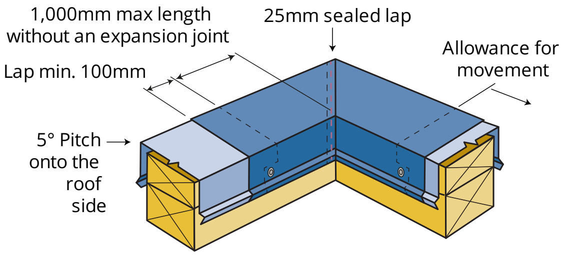

## 8.4.3 Parapet Cappings

Cappings are flashings used to cover the top of a parapet wall to protect the wall from the ingress of moisture. Instead of chasing into the wall and using step flashings, the preferred detail is to cover the inside of the parapet wall with vertical ribbed metal or other cladding material, used in conjunction with an apron flashing. (See 8.4.4B Vertical Cladding (Parapet Flashing and Detail).

Capping corners and expansion joints located at the corners must be sealed within 2 m from each direction of the corner measured on the interior side.

The corner of the wall is a fixed point for the capping, and as thermal movement can only occur in one direction away from the corner, an expansion joint should be provided as shown.

## 8.4.3A Parapet Corner Capping

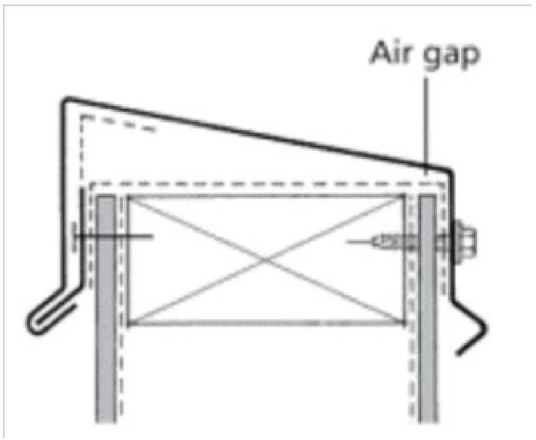



A slope is required to drain water from the top surface and avoid ponding

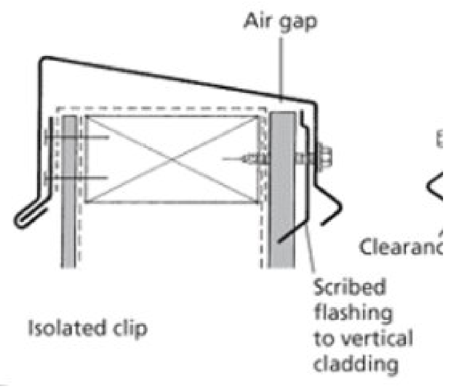
Parapet cappings must have a positive slope of 5˚ onto the roof side, but parapet cappings that follow the slope of the roof do not require any fall across its width. Parapet cappings wider than 300 mm can fall both ways, with the 5˚ drainage angle provided on both sides.

Cappings must not be fixed to the structure through the top of the capping, but can be fixed on the vertical leg by one of three methods. (see drawing 5.3.4. B, C, & D).

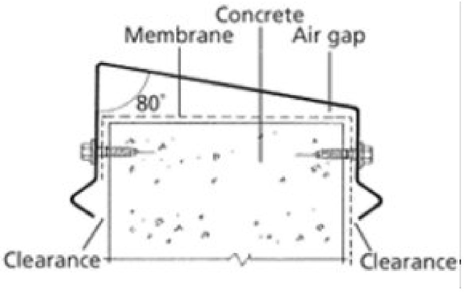
1. A continuous cleat is fastened on the exterior face of the wall with an open hem at the drip for ease of application. After the exterior face of the capping is hooked to the cleat, the capping on the interior side is secured to the parapet using washered fasteners through oversized holes.
2. Intermittent clips are fastened to the exterior face of the wall at 600 mm centres. All cleats and clips should be accurately aligned and clinched after fixing, while still allowing for expansion without chatter or vibration.
3. The capping is fastened to the parapet on both sides using screws with sealing washers through oversized holes.



### 8.4.3B Vertical Fixed Capping with Isolated Clip




### 8.4.3C Vertical Fixed Cladding with Two Fasteners




## 8.4.4 Apron Flashings

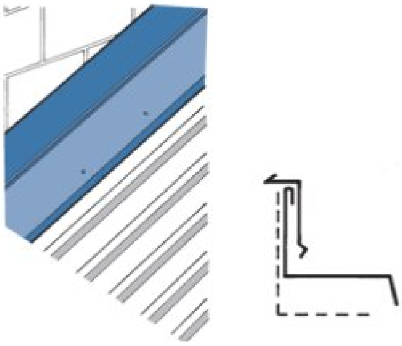
Cladding should not fit tightly onto the horizontal surface of any apron flashing; as it could retain moisture and collect dirt and debris. It should have a minimum clearance of 25 mm to allow for cleaning and maintenance.

Apron flashings should be in position before any cladding is installed. Where the finish above the apron is plaster or the durability of the cladding is 50 years, the hidden apron flashing is also required to have a 50-year durability. This durability can be achieved by using a non-ferrous material for the flashing. Alternatively, a two-piece apron should be used where the over flashing has 50-year durability, and the apron flashing can be renewed independently. (See 8.4.4F Two-piece Apron.)

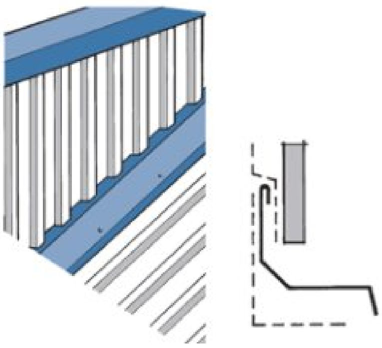
When the parapet walls will be plastered or when other trades are likely to follow the roof cladding installation, the roof cladding and flashings should be protected from damage. Provision should also be made for working and walking on the roof cladding during this time.

Where an apron abuts a block, brick, or concrete wall without any cladding above it, the apron flashing can be weathered by a step or a continuous chased flashing. These flashings can be made from aluminium, stainless steel, or zinc when used with metallic-coated steels and should extend 25 mm into the wall. They should be hooked or mechanically wedged and should be sealed using a compatible, flexible mortar or sealant. Over-clad flashings give better weather protection than chase-cut flashings.

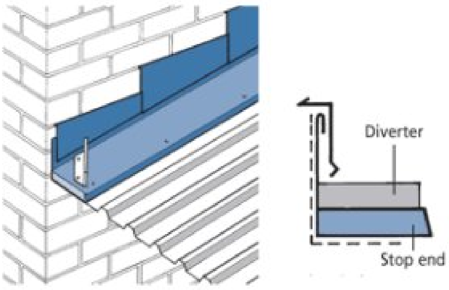
## 8.4.4A Chased Apron



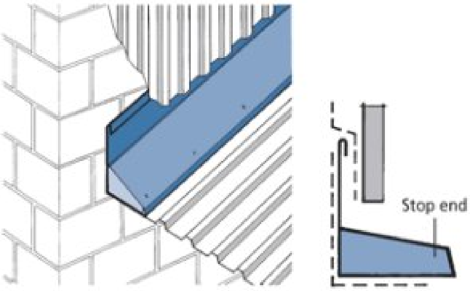
## 8.4.4B Vertical Cladding (Parapet Flashing and Detail)



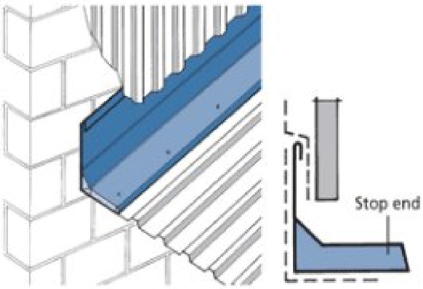
## 8.4.4C Angle Diverter



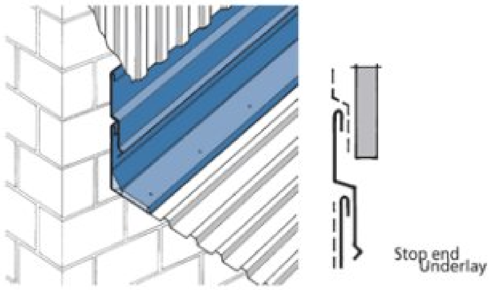
## 8.4.4D Angled Apron — 110°




## 8.4.4E Angled Apron — 45°




## 8.4.4F Two-piece Apron




8.4.4A Chased Apron and 8.4.4C Angle Diverter are not the preferred installation methods for apron flashings. 8.4.4B Vertical Cladding (Parapet Flashing and Detail)shows a better method that provides more positive weathering by covering the wall with vertical metal cladding up to the capping.

It is not possible to ensure that all the water discharged from the apron flashing will be collected by the spouting, unless special provisions are made including:

- an angle diverter should be sealed and fastened to the apron. (See 8.4.4C Angle Diverter);
- the side apron flashing can be folded to 110° ( see 8.4.4D Angled Apron — 110°);
- an apron internal angle flashing can be folded to two angles at 135° (See 8.4.4E Angled Apron — 45°); or
- using a two-piece apron (See 8.4.4F Two-piece Apron).

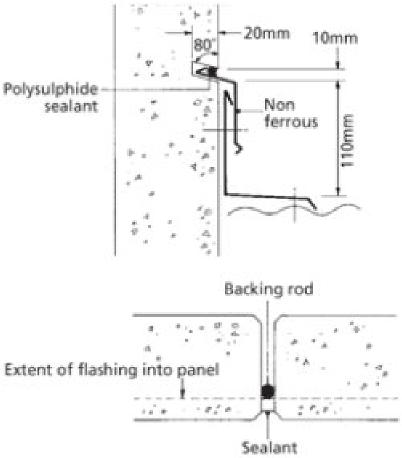
Spouting should be fitted after the wall has been finished and should be clear of the wall cladding.

Aprons should be stop-ended and turned down to weather and bird-proof the end of the apron at this junction.

When flashing a cavity parapet, the apron should be in place before the cavity batten as it is not possible to retrofit the apron. The apron material should have a 50-year durability unless the parapet cladding is easy to replace.

When a chase or rebate (8.4.4G Chase-fixed Flashing)  is not provided, a pressure bar flashing can be used to weather an apron flashing into a concrete tilt-up slab wall.

## 8.4.4G Chase-fixed Flashing



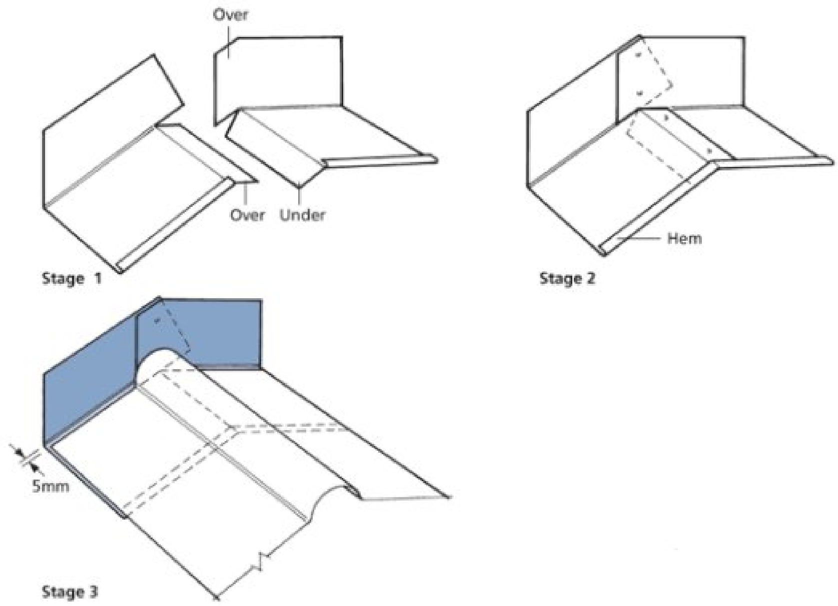

Over-clad apron flashings are always preferred to chase-cut alternatives in structures such as residences where the occurrence of chase-cut weatherproofing failure could have severe consequences.

## 8.4.4.1 Parapet And Apron Capping Terminations

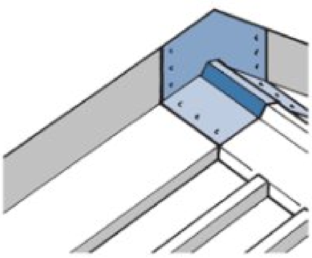
A junction where and apron flashing meets a ridge can be weathered by two methods.

1. By carrying the apron over the ridge and covering the joint with the ridging as shown in 8.4.4.1A Parapet/Apron Ridge Cap.
2. By making a separate saddle flashing as shown in 8.4.4.1B Separate Saddle Flashing.

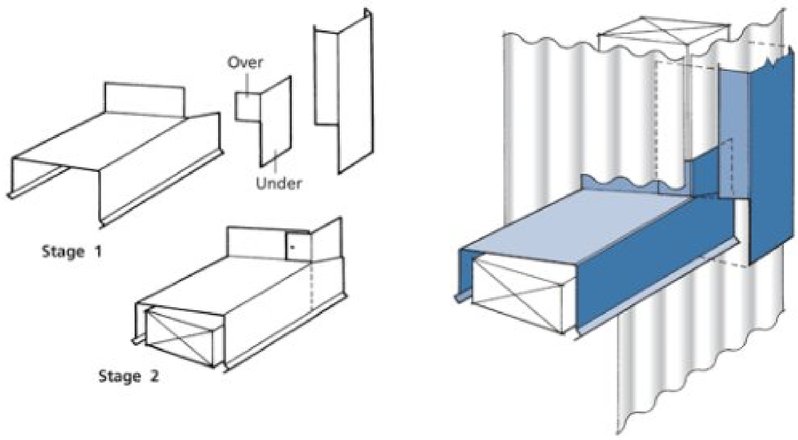
## 8.4.4.1A Parapet/Apron Ridge Cap




## 8.4.4.1B Separate Saddle Flashing

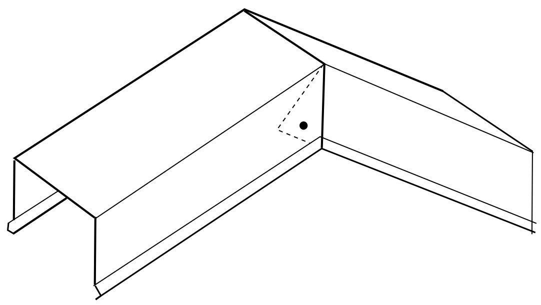


## 8.4.4.1C Corner Abutment

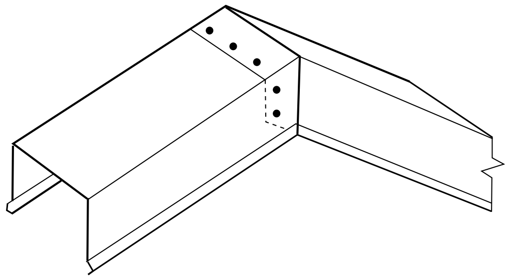



Parapet cappings should have a separate cap at the apex or be joined as shown in 8.4.4.1D One-piece Parapet Ridge.

## 8.4.4.1D One-piece Parapet Ridge



### 8.4.4.1E Two-Piece Parapet Ridge

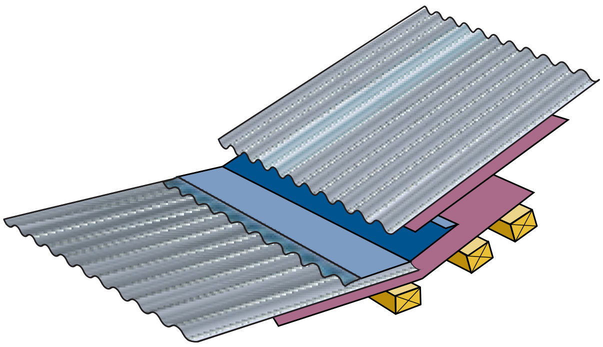


## 8.4.4.2 Change Of Pitch

Differential movement will happen at any change of roof cladding pitch where the sheets are overlapped and butted together. This movement causes noise and deterioration of the coating. A separate apron flashing as shown in 8.4.4.2A Change of Pitch Junction Flashing is required to prevent that.

A junction flashing must be used where sheeting is cut at a change of pitch. The junction must be hooked and have the minimum coverage as required according to the exposure category in 8.3.1 Flashing Laps. The underlay must overlap the flashing as shown.

### 8.4.4.2A Change of Pitch Junction Flashing

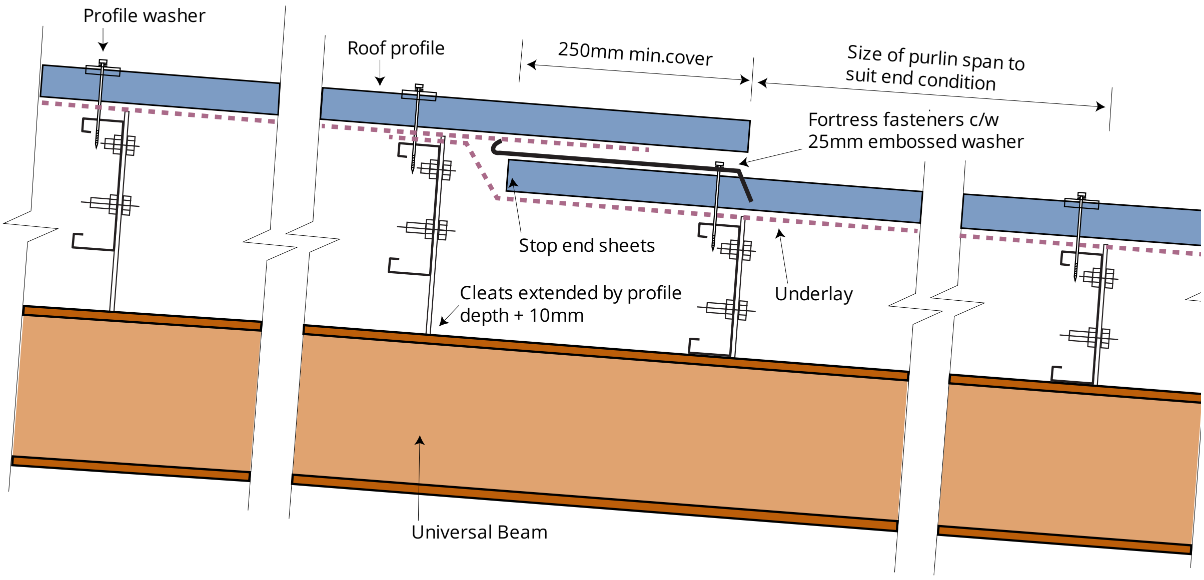


## 8.4.4.3
## Step Apron

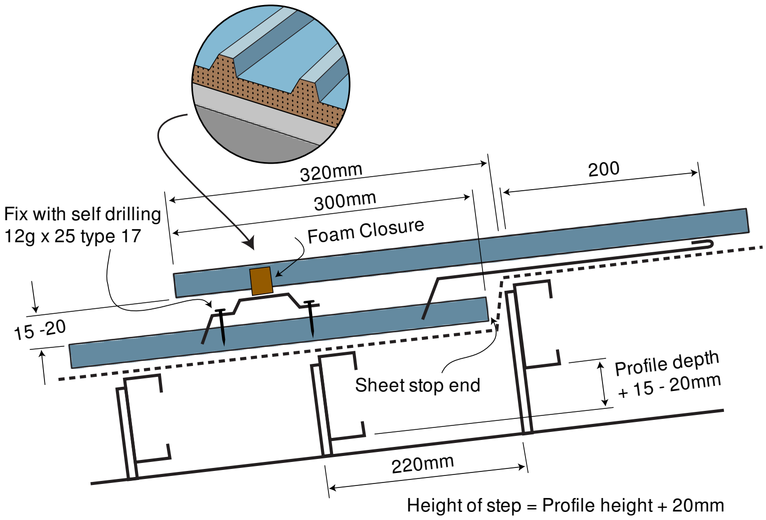
A step apron or waterfall flashing must be used where the length of roof cladding is more than can be transported, or exceeds the recommended length for expansion as shown in 7.3.2 Roof Cladding Expansion Provisions.

The designer should allow a minimum 20 mm step in the purlin height to accommodate a step apron, giving a total change of height equal to 20 mm plus the profile height. The purlin height can be adjusted at the purlin cleat or by using a different size purlin.

### 8.4.4.3A Step Apron Details



## 8.4.4.3B Stepped Roof Flashing




## 8.4.4.4 Eaves Flashing

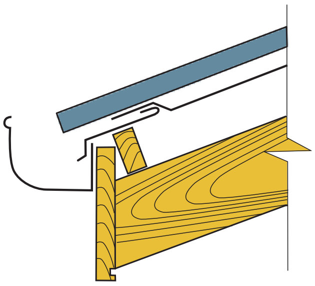
*Gutter eaves flashings are not required for weatherproofing unless the building is in a very exposed location and the eaves are not protected by spouting. They can serve a purpose in many applications of improving the durability of roofing at the eaves (see 4 Durability).*

The flashing should extend into the gutter, and the underlay finishes on the down-slope of the flashing. If there is no over flashing to the gutter, the underlay should be extended into the gutter by a maximum of 20 mm.

Unwashed flashings should be made of durable materials such as organic coated steel, aluminium, or PVC.

Eaves flashings as referred to in E1/AS1 are not required for weatherproofing unless the eaves are unprotected by spouting, but they can make a contribution to durability. (See 3. Durability)

### 8.4.4.4A Over Flashing



## 8.4.5
## Curved Flashings

Drape curved and crimp curved metal roof cladding requires curved barge and apron flashings which may not always have an even radius.

There are two different ways to form curved flashings, all of which require specialist equipment.

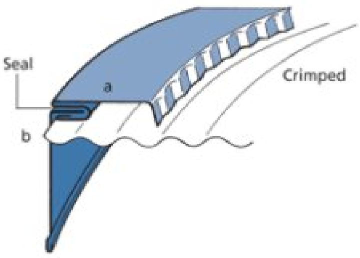
- lock-forming or lock seaming; or
- crimping.

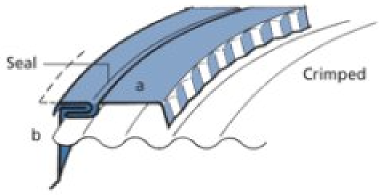
Manufacturing curved flashings is a highly skilled operation and should be done in a factory by skilled workers.

## 8.4.5.1
## Lockseamed Flashings

All lock-seamed flashings should be custom-made to suit the profile shape and the rib distance from the fascia with sufficient downturn on both sides to weather the junction. Lock-seamed flashings are made in two parts, the horizontal (part a) and the vertical (part b). Edges can be either crimped or lock-seamed, as shown in these drawings.

### 8.4.5.1A Lockseamed Curved Flashing




The vertical barge component (part b) can be cut to the curve and lock-seamed, with the horizontal component (part a) hooked and seamed jointed. (See 13.8 Tools Of The Trade.) The outside edge can be crimped as shown here, or hemmed.

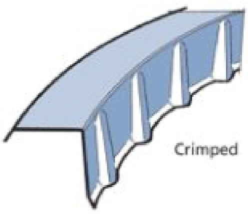
Shallowly curved flashings can be folded straight in one piece and crimped on both edges. Fix the turn-down at the curved rib by “mini-crimping” or “gear-crimping”.

## 8.4.5.2 Crimped Flashings

Crimped flashings are suitable for use on radii of more than 2 m, with the crimp spaced and deformed at regularly spaced intervals. A flat strip should be placed on the template and crimped until the strip fits the template.

*Because the flashings are seen from much closer, domestic clients may find this type of flashing aesthetically unacceptable.*

### 8.4.5.2A Regularly Spaced Crimp (Crimp Flashing)



## 8.5 Fastening Flashings

**Flashings must be fastened in one of three ways.**

- **By primary fastening – fastening into the main structure.**
- **By secondary fastening — fastening into the cladding.**
- **By means of clips, cleats or seams to allow for differential movement of the roof cladding and the flashings.**

**For full details on fixings, see 14.3 Fasteners.**

### 8.5.1 Primary Fasteners

Primary fasteners are fixings that attach flashings to the structural building frame and which should withstand all the loads applied to the cladding, including expansion provisions. Primary fasteners are relied on for structural performance. Flashings should be fastened at a point within 25 mm from the exposed edges of the flashing, and the primary fastener spacing should be to each structural member it crosses.

Flashings should be fixed on both edges.

Putting bonded or embossed washers under all primary fasteners through the horizontal upper surface of flashings improves weathertightness.

### 8.5.2 Secondary Fasteners

Secondary fasteners are fixings that attach flashings to sheets and one another to transfer loads and provide lap sealing. Rivets and stitching screws are secondary fasteners used to fasten flashing laps. They are subject to shear loading due to expansion and differential movement.

Sealing washers are required on all secondary fasteners, except under rivets which should themselves be sealed or self-sealing.

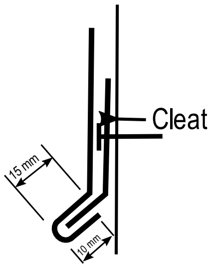
### 8.5.3 Flashing Cleats

*A flashing cleat is a continuous metal under-flashing installed behind the leading edge of a metal capping or flashing. Cleats secure cladding or flashings to the substrate or structure using a slip joint or by crimping the leading edge of the flashing to the cleat.*
*Cleats and clips should be accurately aligned and clinched after fixing to avoid vibration or chatter, but should still*

*allow for expansion of the flashing.*
*Cleats are fastened to the substrate using mechanical fasteners and should be made from the same metal as the flashing or sheeting.*

To allow for differential expansion and contraction, the flashing should be securely hooked to the drip edge of the cleat but should not be attached directly to it.

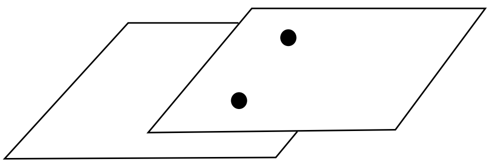
### 8.5.3A Flashing Secured to a Cleat



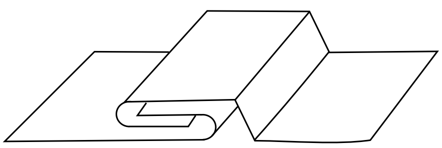

## 8.5.4 Seams

*Flashings can be joined together by various types of seam to avoid a plain lap joint without sealant. If the joint is likely to retain moisture and it is required to be sealed, the sealant should be introduced into the joint before it is completed.*

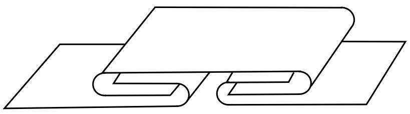
### 8.5.4A Lap Seam



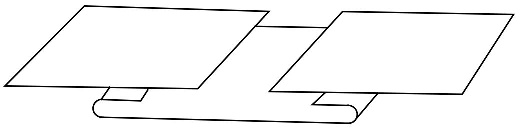
### 8.5.4B Lock Seam



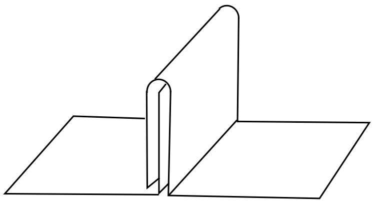
## 8.5.4C Drive Cleat



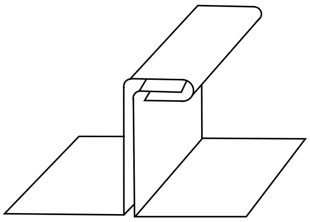
## 8.5.4D Soaker



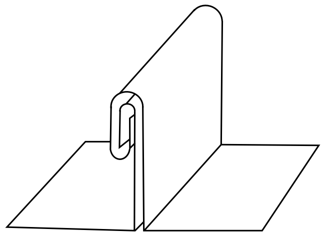
## 8.5.4E Standing Seam



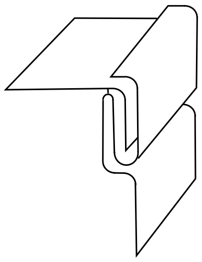
## 8.5.4F Single-lock Standing Seam



## 8.5.4G Double-lock Standing Seam



## 8.5.4H Pittsburgh Lock



## 8.6 Sealants

*Sealants play an important part in cladding because AZ or paint coatings cannot be sealed using solder.*

*The purpose of sealants used in the joints between metal roof and wall cladding and flashings is to prevent the entry of rain or snow and to exclude dirt, debris, and moisture by capillary action. They may also have varying degrees of adhesive action.*

*Sealants are generally Neutral Cure silicone or Modified Silicone (MS) types. The latter is generally paintable. Proprietary self-adhesive tape sealants are also entering the market and give excellent performance in certain conditions. Acid cure sealant, designed to bond to inert surfaces such as glass, must not be used.*

***Designs using sealants to seal sheet components must always include a mechanical fastening such as a screw, rivet or a mechanical seam.***

*Generally, the function of a sealant is carried out by that sealant being sandwiched in the joint. In most cases, the post application of sealant to the outside of a joint is both futile and unacceptable.*

*The sealant does not require significant total adhesive strength, but it should bond positively to both surfaces as a continuous layer. To ensure complete sealant cure, the width of sealant in a lap should not exceed 25 mm when compressed*

### 8.6.1 Methods Of Sealing

There are two main methods of sealing metal sheets — gun applied sealants and self-adhesive tapes.

Sealants should have a low resistance to compression so that metal sheets can be brought closely together by their fasteners and not held apart by the sealant.

### 8.6.2 Surface Preparation

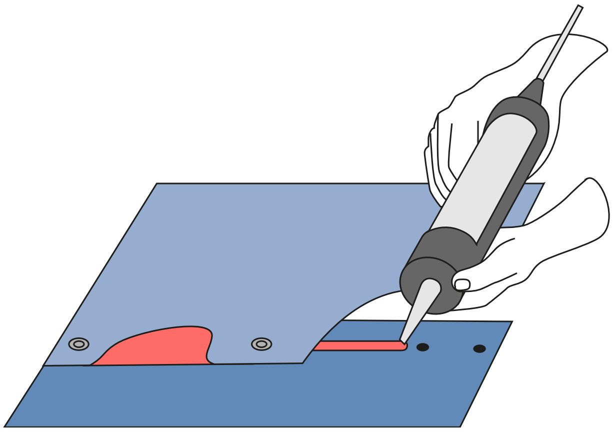
For adequate bonding, all surfaces must be clean, dry and free from contaminants, such as rolling oils, dirt or dust.

### 8.6.3 Sealant Extrusion And Placement

Sealant should be gun-applied in a continuous flow to provide a joint without gaps or voids. This will prevent the entry of both condensation from above and water drawn up by capillary action, either of which can cause metal corrosion.

*After placing the sealant cartridge in the gun, the tapered nozzle should be cut with a sharp knife at an angle of 45 ° at a position which would provide a bead of sealant approximately 6 mm in diameter.*

## 8.6.3A Applying Sealant



Sealed rivets are the preferred fastener. The stem holes of unsealed blind rivets must be sealed with silicone, which can attract dust and look unsightly.

Sealant should be placed in a continuous bead close to the weather end, covering any pre-drilled rivet holes. If a complete ring of sealant is applied around the fastener, an air pocket forms which compresses during tightening of fasteners. It can blow a channel, thus preventing an effective seal.

The best method for lap fabrication is.

- Assemble and drill the components. Rivets should be positioned at 50 mm spacings.
- Separate the components and remove any drilling swarf.
- Remove any strippable film.
- Clean the joint.
- Apply a continuous sealant bead as described above.
- Relocate the components, align the holes and fasten.
- Externally seal the centre of all rivets if required.
- Remove surplus sealant after it has cured (not while uncured), to avoid smearing.

When placing the overlapping sheet, care should be taken to avoid disturbing the sealant when fastening.

Excess sealant should be removed with a plastic spatula or purpose made plastic scoop as excess sealant collects dirt that is unsightly.

Visible excess of sealant is not an acceptable trade practice.

## 8.7
## Profile Closures

Profiled closures are available for all profiles. As they restrict the free movement of air, their use should be restricted to where their use is required for weatherproofing or other reasons, such as maintaining internal pressures.

High fronted spoutings or scribed, ventilated metal closures are the preferred methods of preventing ingress of wind-blown moisture; and for vermin, an eaves comb which self-adapts to any profile.

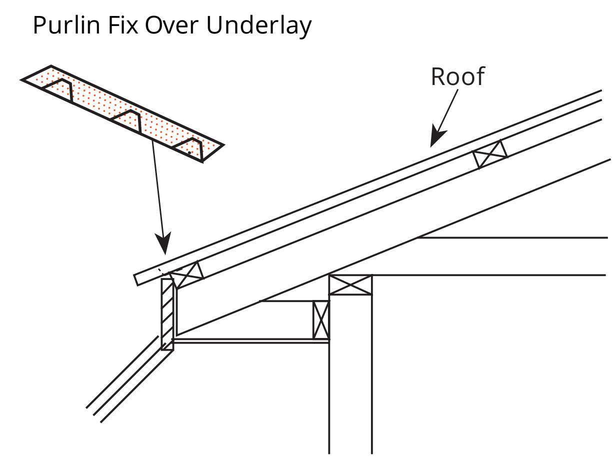
Profile closures should be a closed cell type rather than bitumen impregnated open cell foam.

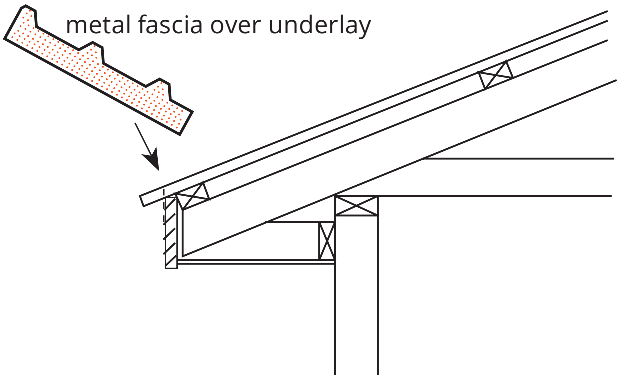
### 8.7A Filler Blocks


### 8.7B Ridge and Eave Filler Blocks

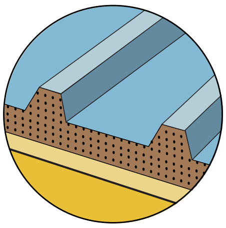
*Filler blocks should be used compressed between the sheets and supports or flashing and should be secured by the cladding fastener or adhesive sealant*

## 8.7C Filler Blocks at the Eaves

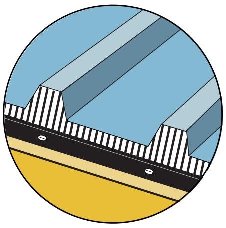



## 8.7D Foam Filler Blocks



## 8.7E Eaves Comb



## 8.7.1 Soft Edging

To prevent the ingress of weather, dirt, or birds, it is common practice in New Zealand to close the openings created by the pan and ribs of profiled sheets using notched metal flashings or soft edging. Lead was the traditional material for this application, but as it is incompatible with AZ coatings, soft aluminium edging or composite materials are offered as an alternative.

Proprietary soft edging is available for corrugated and low trapezoidal profiles, consisting of an expandable aluminium mesh with a flexible backer.

All soft-edged flashings should be primed and colour painted before installation — but the preferred option is for the paint finish on soft edges to be factory painted under controlled conditions.

Soft-edged flashings are available in a partially-backed form to facilitate passive ventilation at the apex. (See Internal Moisture)

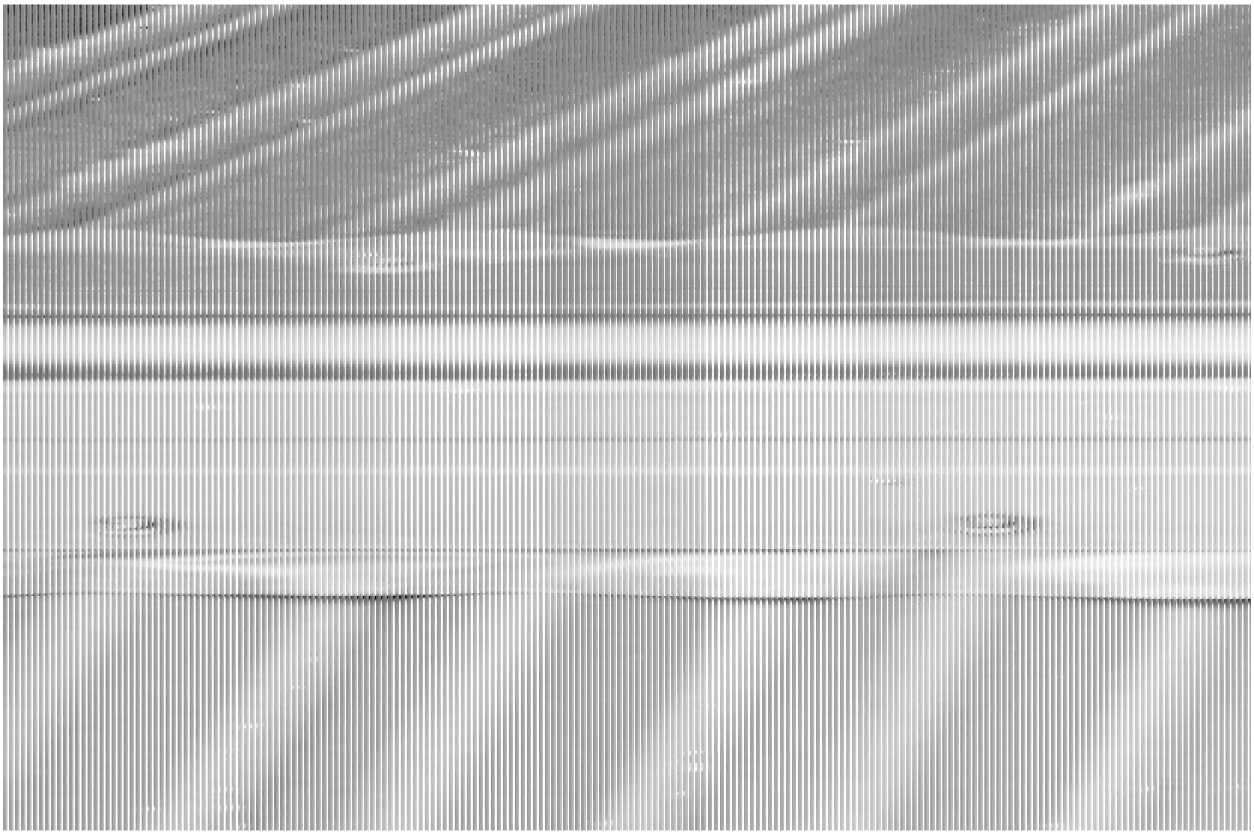
## 8.7.2 Notched Edging

Where the profile height exceeds 30 mm, a notched flashing is the preferred option.

All scribed edges should have clearance to avoid damaging the coating of the roof sheet. The scribed metal edge of any flashing must have a clearance of 2 mm to 5 mm.

# 8.8 Flashing Buckling

## 8.8A Buckled Ridge Flashing



Before any transverse flashings are fixed, the framing timber must have a maximum moisture content of 18%.

Transverse flashings, such as ridging, are sometimes prone to compressive buckling which is blamed on metal expansion but is usually due to timber shrinkage, and a phenomenon known as compression timber.

## 8.8B Compressed Timber

*Compression wood has a darker appearance in the early wood (summer) growth rings; to visually distinguish such severity levels in sawn timber accurately requires microscopic identification. (Source: Rooflink)*

Abnormal growth causes this defect in timber, which can cause shrinkage ten times more shrinkage than normal.

It is not easy to recognise compression timber visually and roofers are advised to measure the moisture content, particularly of ridge purlins, before fixing. Framing timber must have a maximum moisture content of 18% before any transverse flashings are fixed.

Alternatively, use steel top hat purlins.

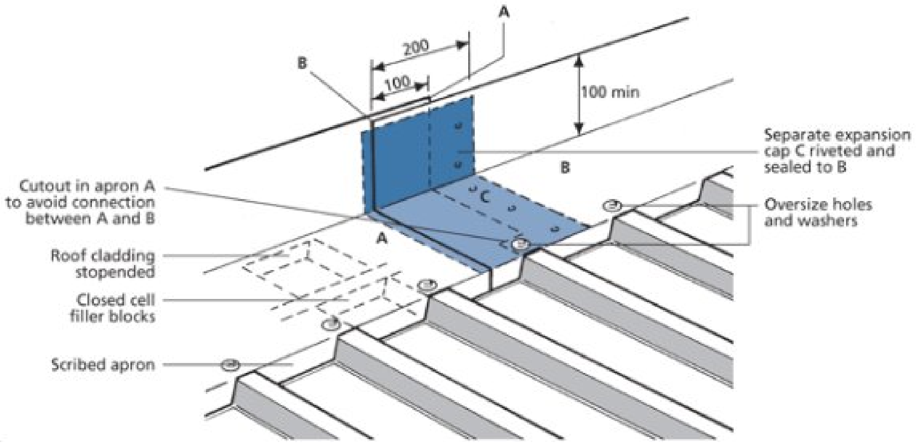
# 8.9 Flashing Expansion Details

Expansion should be considered at the design stage, and the flashing details should be included in the working drawings and tender documents. As flashings cannot move in the lateral direction without stress, they should have some provision for longitudinal expansion when their length exceeds 18 m, or for lesser distances for visual flashings such as fascias and facades.

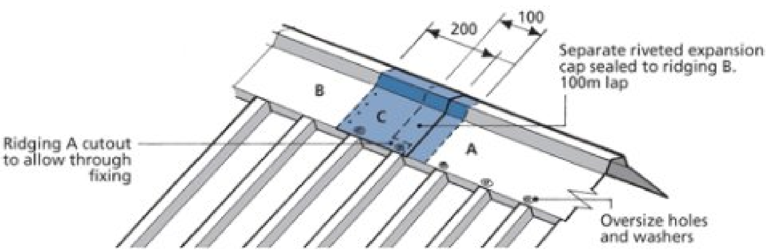
When using an expansion joint, independence of movement should be assured by the omission of any fixing through both sides of the joint. Preferred and acceptable slip joint expansion details are shown in 8.9A Apron Slip-joint and 8.9B Ridge Slip-joint. Soaker expansion joints relying on sealant should not be used.

Slip joints require sealants, not to make them weatherproof, but to exclude dust and dirt from two close fitting surfaces, which can retain moisture by capillary action and cause corrosion. Rivets and other fasteners must not prevent movement of the slip joint.

## 8.9A Apron Slip-joint




## 8.9B Ridge Slip-joint




# 8.9.1 Flashing Expansion

**Before any metal roof or wall cladding or flashings are fixed the framing timber must have a maximum moisture content of 18%.**

**Transverse flashings, such as ridging, are sometimes prone to excessive buckling which is blamed on metal expansion but is usually due to timber shrinkage, and a phenomenon known as compression timber. Abnormal growth causes this defect in timber, and it can shrink up to 10 times more than normal. It is not easy to recognise compression timber and roofers are advised to measure the moisture content, particularly of ridge purlins, before fixing.**

**An alternative is to use steel top hat purlins.**

**Fixing roof cladding should be treated in the same way as internal linings, i.e., do not fix transverse flashings when the moisture content of any timber is more than 18%. The thickness of flashings should always comply as specified in 8.1 Flashing Materials**

*If flashings are positively fixed, framing timber that does not meet this requirement can cause failure of ridging and flashings due to timber shrinkage when drying.*
*The metal expansion allowances quoted in many publications can be misleading because the information is based on theoretical metal expansion values and is not related to real-world conditions.*

*Figures published for metal expansion rates are given linearly per degree, but it does not take into account the many other factors that mitigate the theoretical figure. (See 7.3 Thermal Expansion And Contraction.)*

It is necessary to make provision for cladding and flashing movement; when long lengths are used and positively screwed or riveted together, they should be regarded as one length.

The maximum length before expansion provision should be made for either cladding or flashings will vary according to colour, micro-climate, ventilation and fixing spacings. It is , however, possible to provide indicative figures based on a study of empirical data over time. The maximum recommended flashing length without any expansion provision is similar to that of roof cladding, i.e., every 12 m for coated steel flashings.

Aluminium rivets, which have a low shear value, will fail when there is no provision made for expansion in flashing lengths of over 12 m. Using aluminium joints is only acceptable if they are used at the prescribed distances, and are not used to replace expansion joints.

Lengths of coated steel ridging, cappings, and apron flashings over 12 m should have a slip joint as described in 8.9 Flashing Expansion Details.

Inadequate provision for expansion can also cause Roofnoise.

## 8.9.2 Building Expansion Joints

Expansion joints should be designed to accommodate contraction and expansion. Expansion joints should be detailed and constructed to a minimum height of 100 mm above the roof cladding, and curb-type expansion joints should be designed and installed to ensure drainage of the roof and to prevent any damming of water.

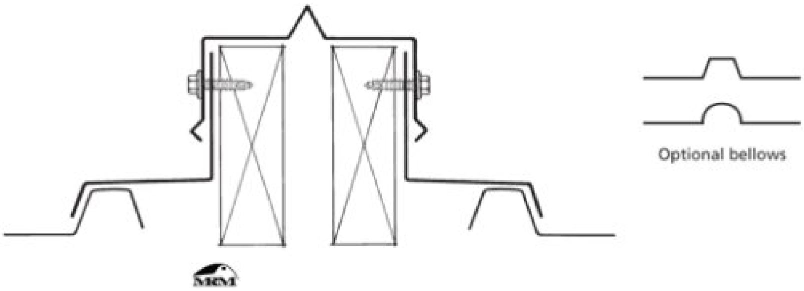
Wood curbing secured to the substrate on both sides of an expansion joint should be flashed with a metal capping capable of acting as an expansion joint cover.

Expansion joints have two main designs.

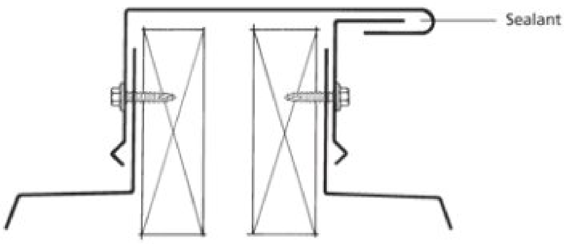
1. A 8.9.2A One-piece Expansion Joint to accommodate movement using a central bellows or roll that allows the flashing to be positively fixed on both sides.

2. A two-piece design to accommodate movement by the use of hemmed edges, with sufficient clearance for the expected movement.

## 8.9.2A One-piece Expansion Joint




## 8.9.2B Two-piece Expansion Joint




Both of these designs are shown as a parapet following the pitch of the roof. Where this is not the case, the top of flashing should have a 10˚ slope as for all other parapet flashings. (See 8.4.3 Parapet Cappings.

Metal wall construction joint flashings that are embedded in the wall should be made with a bellows or other means of accommodating movement without fatigue and have a durability of 50 years.

## 8.10 Metal Wall Cladding Flashings

Flashing details for cladding using profiled metals should:

- have two lines of defence at any point,
- not rely entirely on sealant,
- not unnecessarily bridge the cavity, and
- give water a means of escape when it does get in.

Details from WANZ, cladding suppliers, or bespoke solutions may be used. In the case of bespoke solutions, it is critical that the intersection of the different elements is considered holistically, particularly at the critical head/jamb flashing intersection. Changing one element of a proprietary solution may have unconsidered ramifications on the performance of other elements.

### 8.10.1 Fixing Horizontal Corrugate Cladding

*Because horizontal cladding emphasizes the defects in the framing line far more than vertical cladding does, the plane of both the horizontal and vertical supports should be straight within a tolerance of 5 mm in 10 m, and there should be little or no twist between the vertical and horizontal planes of framing members.*

The cladding contractor should inspect and approve the standard of framing before the commencement of any cladding installation. The use of 0.40 mm coated steel cladding is likely to show any deviation in the line of the framing and 0.55 mm is, therefore, the preferred choice.

The support centres should be reduced for horizontal cladding and a minimum flashing thickness of 0.55 mm for steel or 0.9 mm for aluminium should be specified. The width of the supports will be determined by the method of jointing and secondary framework may have to be provided, with all support fixings being counter-sunk.

Fix horizontal cladding in the pan as that provides a stronger, more economical and aesthetic fastening than crest or rib fixing. The number, spacing and the position of the fasteners are determined by the wind design load for the building. See 3.16.5 Wind Load Span Graphs.

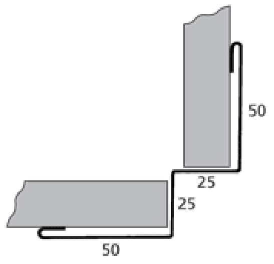
For aesthetic reasons only, or where the cladding is at eye level, the number of fasteners may have to be increased to every second corrugation for corrugated steel, and one primary fastener placed at every trough and secondary fasteners at 500 mm centres for other profiles.

A simple and aesthetically pleasing detail to join abutting lengths of horizontal cladding is to provide a vertical break using a top hat or tee section flashing which the cladding sheets butt up to. As this is an express detail, the sheet ends are exposed and must be cut accurately, cleanly and at a consistent length to provide a tidy looking joint.

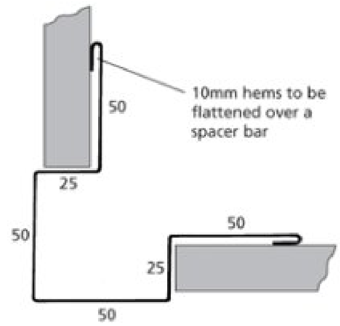
Designers should be aware of the likelihood of condensation when horizontal metal cladding is directly fixed to a lined and insulated wall The COP recomends sealing horizontal laps with lap tape or sealant. See 8.8.5 Sealed Laps and 8.8.6 Strip Sealants.

A ventilated cavity is the preferred option. See 10.2 Condensation.

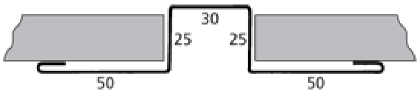
## 8.10.1A Internal Corner Flashing



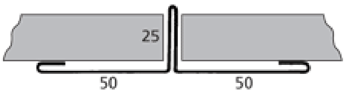

## 8.10.1B External Corner Flashing




## 8.10.1C Jointer Flashing



## 8.10.1D T Flashing



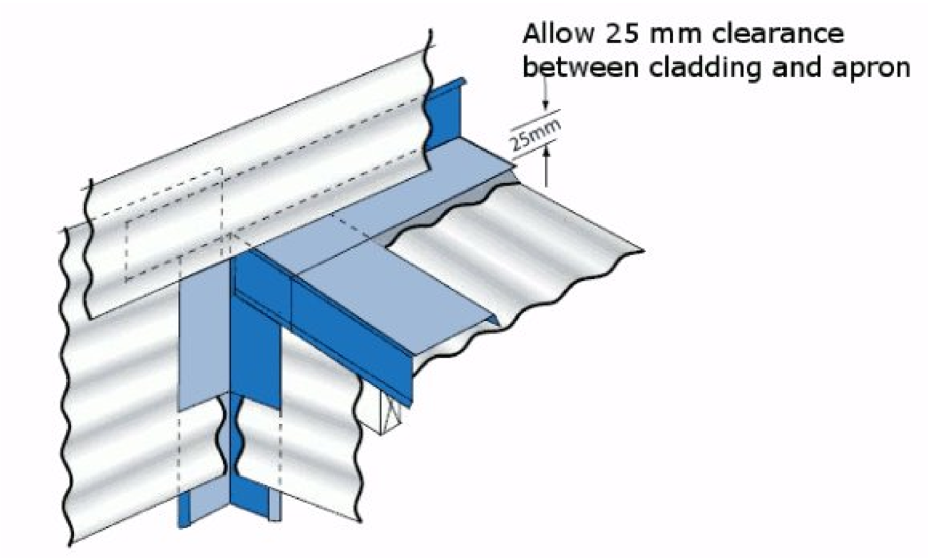

The COP recommends using the details in 8.10.1C Jointer Flashing when sheets exceed 8 m to allow for ease of installation and thermal expansion. Foam filler blocks are recommended for exposed sites.

Butt flashings are not a recommended detail in areas of high design wind load. External flashings should be provided instead of, or in addition to, the butt joint flashings and they should be used in conjunction with stop-ends and filler blocks.

The fasteners in horizontal cladding should be clear of the hemmed soaker and should not penetrate the flashing.

*At an intersection between a horizontally clad vertical wall and a lean-to or similar at a lower level, the intersection can be flashed as shown below.*

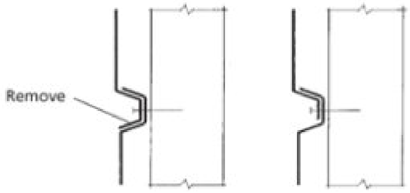
## 8.10.1E Horizontal Cladding to Lower Roof



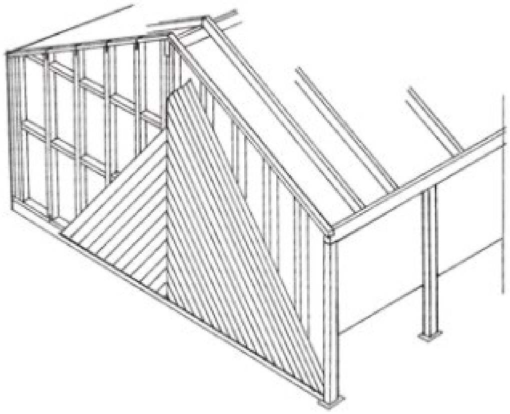

*When profiled metal is used 'inside-out' as a wall cladding, it is better practice to cut the overlap back to the plane of the structure. See 8.10.1F Horizontal Cladding Lap. Penetrations in horizontal or vertical metal cladding should be installed similar to roof penetrations. For round penetrations, a proprietary boot flashing can be used. See 9 External Moisture Penetrations.*

*The requirements for horizontally fixed cladding also apply when the cladding is used at an angle other than vertically or patterns, such as a chevron style. Where sheets are placed on an angle, the lap should be placed* *downside to shed the water and a soaker flashing provided to drain the run-off.*

## 8.10.1F Horizontal Cladding Lap




## 8.10.1G Chevron-Style Cladding



# 8.11 Safety

The person who cuts a hole greater than 600  mm x 600 mm in the roof is responsible for safety precautions, preventing workers from falling through the gap. A hole of this size is regarded as a hazard under the Health and Safety at Work Act.

# 9 External Moisture Penetrations

*This section should be read in conjunction with 6 External Moisture Overview and 8 External Moisture Flashings.*

A penetration is any hole cut in a roof or wall cladding to accommodate projections such as pipes, ducts, chimneys, roof lights doors and windows.

This section focusses on roof penetrations only. The type of penetration design is determined by:

- the size of the hole,
- shape,
- the roof pitch,
- the type of roof,
- the catchment area,
- placement on the roof, and
- aesthetic requirements.

Designers are urged to consider what type of penetration design matches the building application and their customer's needs, and detail accordingly, rather than allow the installer to make an on-site decision.

Many of the penetration details drawn in the Code of Practice (COP) are included in a step by step *How -To Guide* published by the Roofing Association of New Zealand. A copy of this may be obtained by contacting info@roofingassn.org.nz.

## 9.1 Penetrations Minimum Pitch

Penetrations may be executed in roofs of any pitch down to the limit of 8° for corrugate and 3° for other profiles. Penetrations are allowed in the portion of curved roofs where the pitch falls below these limits, providing the penetration flashing bridges the apex and terminates where the pitch is a minimum of 3°.

## 9.2 Additional Support

Terminating a sheet above and below a penetration creates an end span situation and sheet support and fastener patterns should be checked accordingly, or additional support must be provided. (See 3.5.8 Continuity.)

Penetrations requiring removal of a roof section greater than 300 mm x 300 mm require additional supporting framework. Ideally this should be in position before the roof cladding is fixed; alternatively, the supporting framework should be in position before cutting a hole in the cladding.

The additional support for larger penetrations must have the same strength as the adjacent purlins. Purlins and the support structure must be designed to take the additional weight of any plant exceeding 100 kg. Structural members must not be removed without engineering calculations.

### 9.2.1 Penetrations Safety

The person who cuts a hole greater than 600 mm x 600 mm in the roof is responsible for safety precautions, preventing workers from falling through the gap. A hole of this size is regarded as a hazard under the Health and Safety in Employment Act.

# 9.3
# Penetration Durability

**All fittings and materials above a penetration must be made from compatible materials and there must be no runoff onto the roof from incompatible materials or corrosive discharge.**

**Condensate and outflow from any sources such as air conditioning units, solar units or hot water pipes must not be discharged onto metal roof cladding but must be separately drained to an inert gutter or downpipe.**

Level back curbs will not have the same durability as arrowhead or cricket designs and may require maintenance of the coating to match the durability of the roof cladding.

# 9.4 Penetration Positioning

The positioning of the penetration in relation to the apex, eaves and other architectural features must be taken into consideration when selecting the type of flashing to be employed.

## 9.4A Penetration Type at Recommended Position

## 9.5 Penetration Design

It is the designer's responsibility to select the type of penetration flashing appropriate to the design requirements and the client's expectations. Penetrations can be broadly put into two categories: Sheetmetal flashings and Boot flashings

### 9.5.1 Sheetmetal Penetration Flashings

Sheetmetal penetration flashings can be classified as:

#### 9.5.1A Sheetmetal Flashing Classification

| Back Tray | Curb Design |
|---|---|
| Over Profile (Watershed) | Level |
| | Arrowhead |
| | Cricket |
| Under Profile (Soaker) | Level |
| | Arrowhead |
| | Cricket |

The first decision should be the back flashing, should it be over the profile (watershed) or under the profile (soaker).

### 9.5.2 Watershed Back Flashings

Watershed back flashings are easy to install and to weatherproof, particularly if the roof is already in place. The drawbacks are their limits in width and, sometimes, noise or condensation issues. Long lengths of watershed flashings may require multiple end laps which are vulnerable to leakage. Where there are end laps or foot traffic is expected on the watershed flashing, the flashing must be supported in the pan or the profile by rigid closed cell foam or similar.

In many residential cases where the flashing is visible, the aesthetic values of watershed flashings may render them inappropriate for this application, unless the penetration is situated close to the apex.

The maximum width of a watershed flashing is controlled by the coil width of 1.2 m The practice of making wider watershed flashings by running flashings horizontally with laps at 1.1 m is not acceptable, as the numerous joins are prone to leakage. Wider watershed flashings can be fabricated using longitudinal standing-seam techniques on suitable support.

### 9.5.3 Soaker Back Flashings

Soaker back flashings are visually attractive and are less prone to noise or condensation issues. They are relatively easy and economical to install at the time of roof laying, but more difficult and costlier if post installation is required.

## 9.5.4 Curb Design

### 9.5.4.1 Level Back Curbs

Level back curbs are the most common solution for flashing penetrations and are the easiest to fabricate and install.

They may tend to collect debris as they have little or no transverse fall, which can limit durability. However, with normal maintenance when manufactured from the same material as the roof they should achieve the durability requirements of the NZBC.

For penetrations wider than 600 mm, or those in aggressive environments or in situations where maintenance is difficult, a freer draining design such as an arrowhead or cricket is preferable.

### 9.5.4.2 Arrowhead Back Curbs

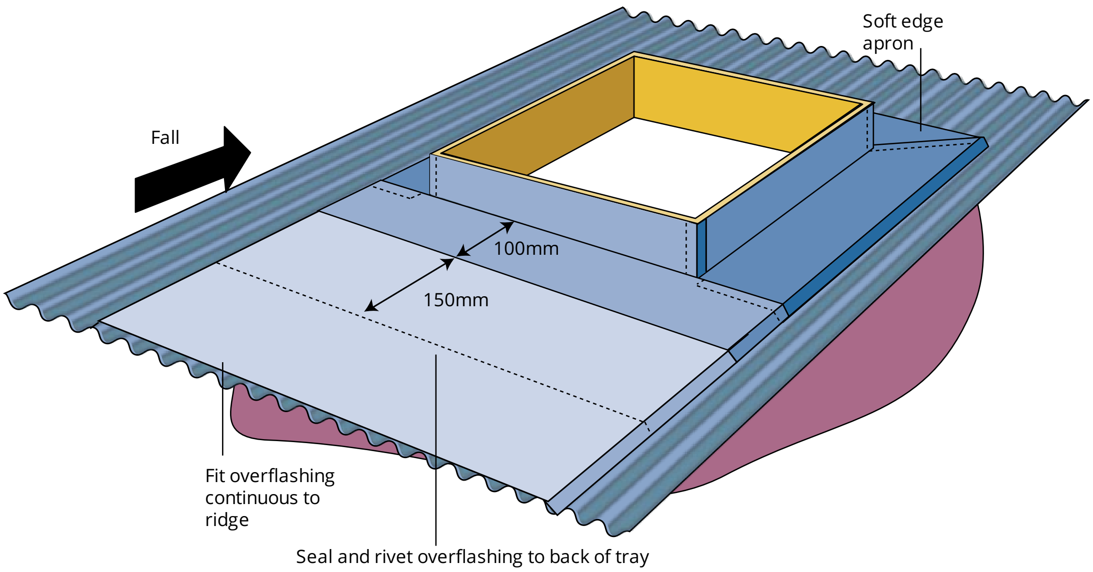
Arrowhead back curbs have a diverter that provides transverse fall for diverting rainwater, enabling them to accommodate bigger catchment areas and self-cleanse. They have a small flat area at the base of the arrowhead that may require maintenance.

### 9.5.4.3 Cricket Back Curbs

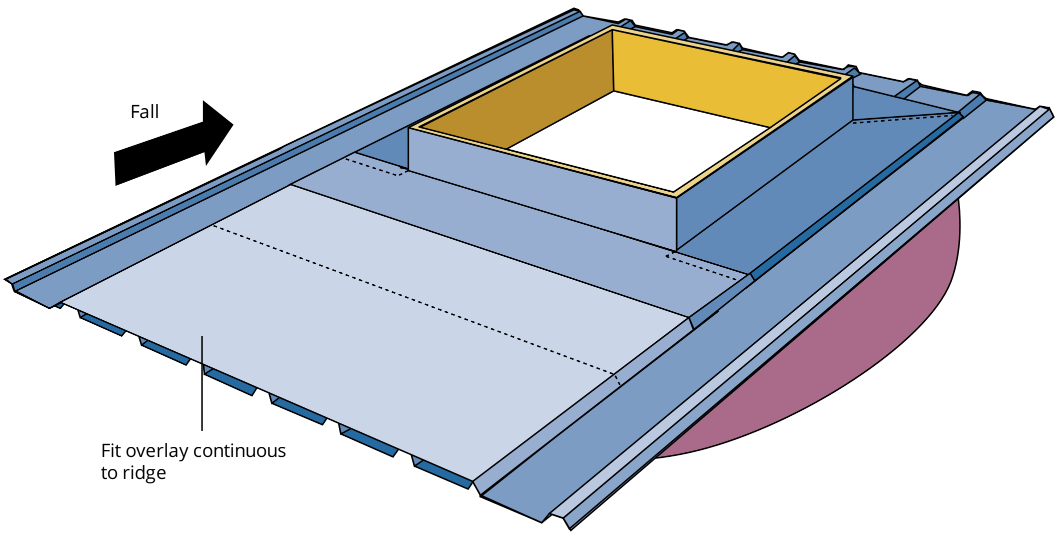
Cricket back curbs divert water with less turbulence than either arrowhead or flat back curbs and have no flat areas to catch debris. They may be fabricated from the same material as the roof or welded from 1.6 mm aluminium and powder-coated to match the roof colour, to give a durable and matching solution. They offer the most durable and weathertight solution to penetration back kerbs.

## 9.5.5 Sheetmetal Flashing Drawings

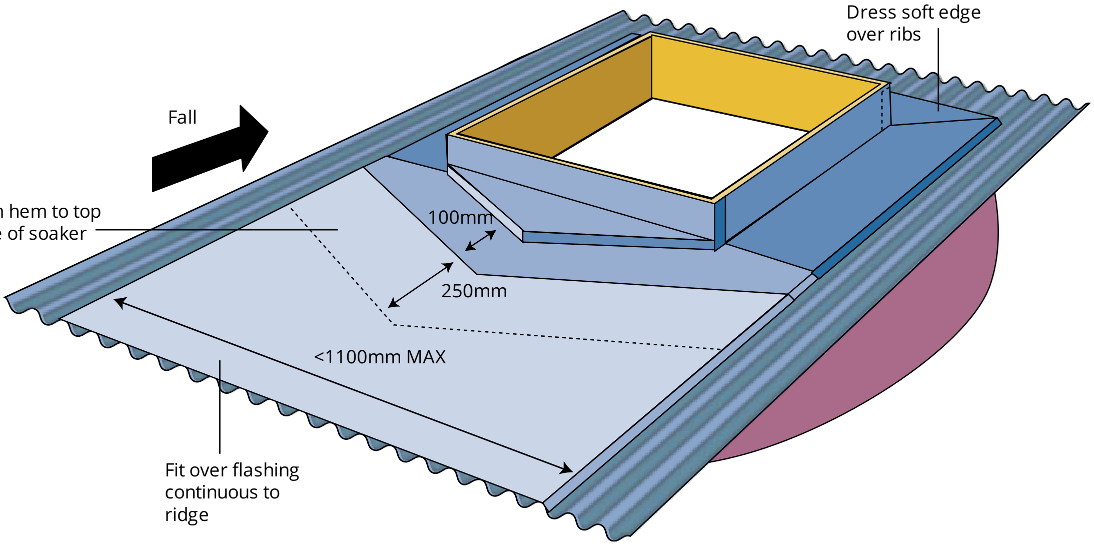
## 9.5.5A Level Over Flashing on Corrugated Profile



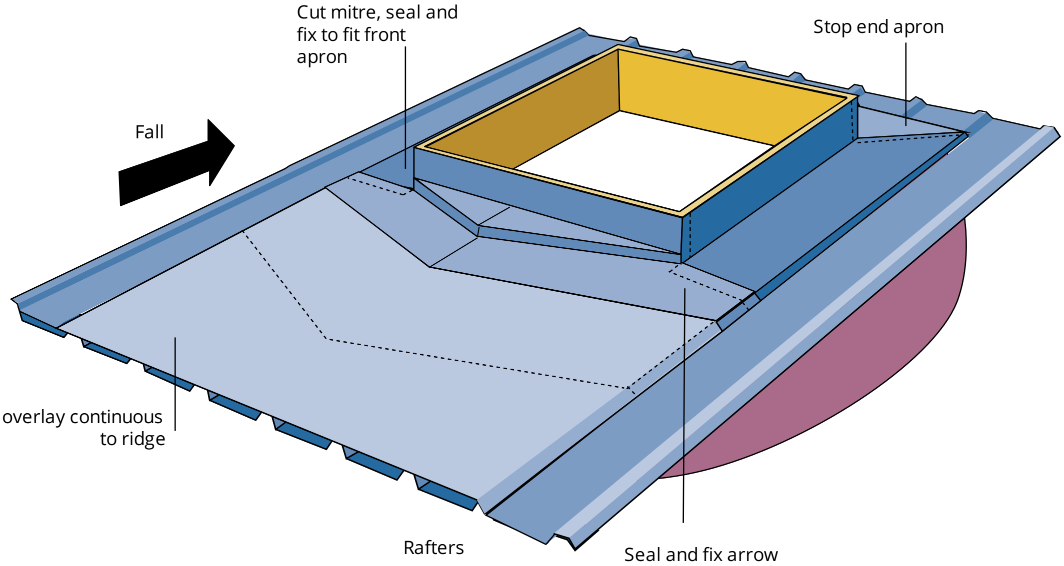

## 9.5.5B Level Over Flashing on Trapezoidal Profile



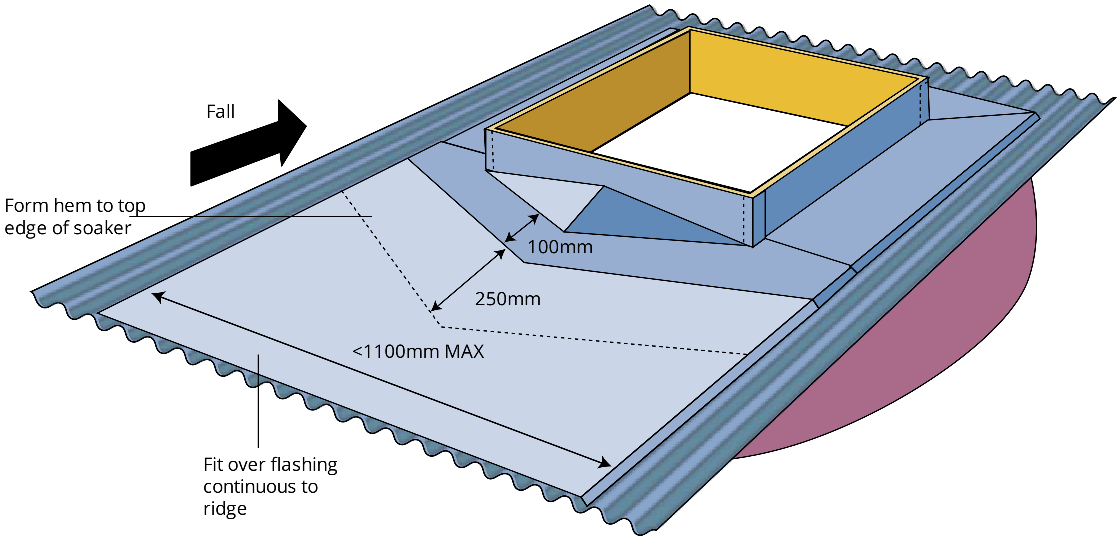
## 9.5.5C Arrowhead Over Flashing on Corrugated Profile



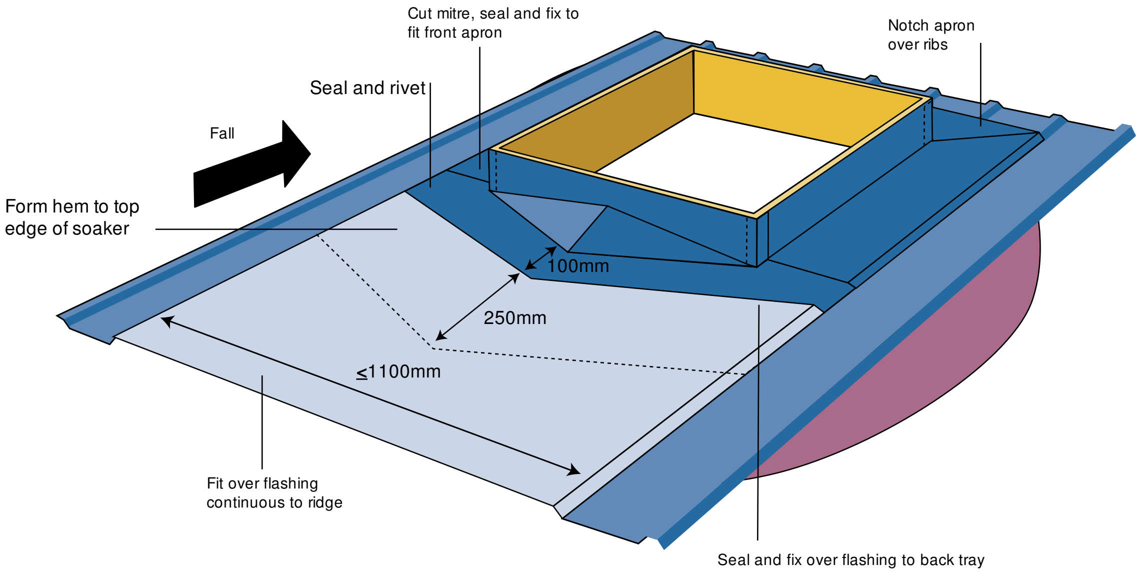

## 9.5.5D Arrowhead Over Flashing on Trapezoidal Profile



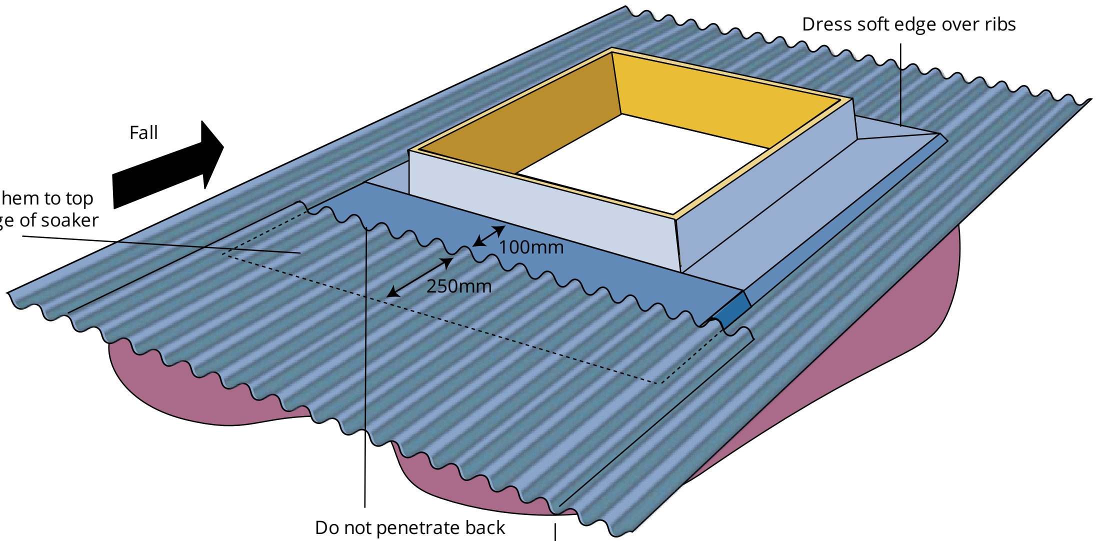
## 9.5.5E Cricket Over Flashing on Corrugated Profile



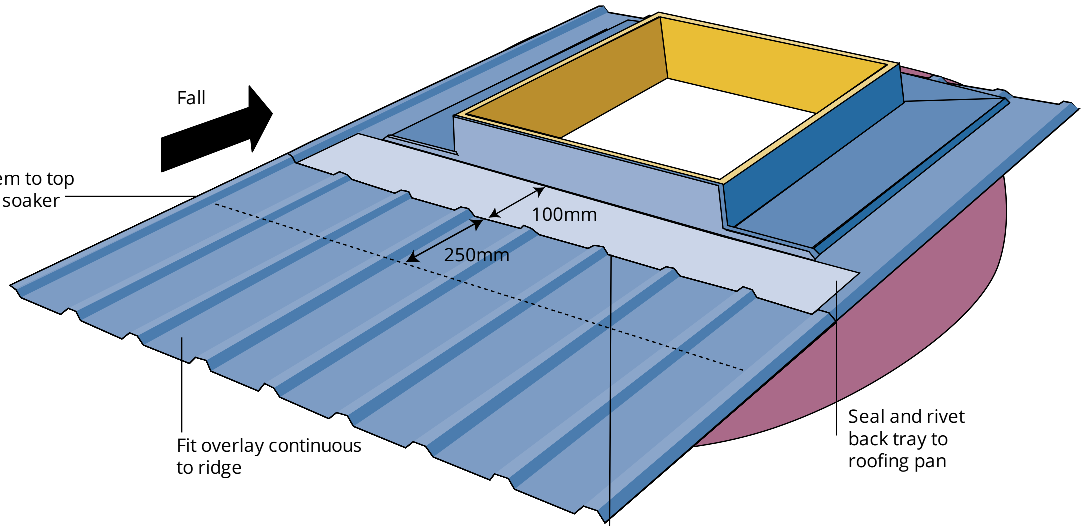

## 9.5.5F Cricket Over Flashing on Trapezoidal



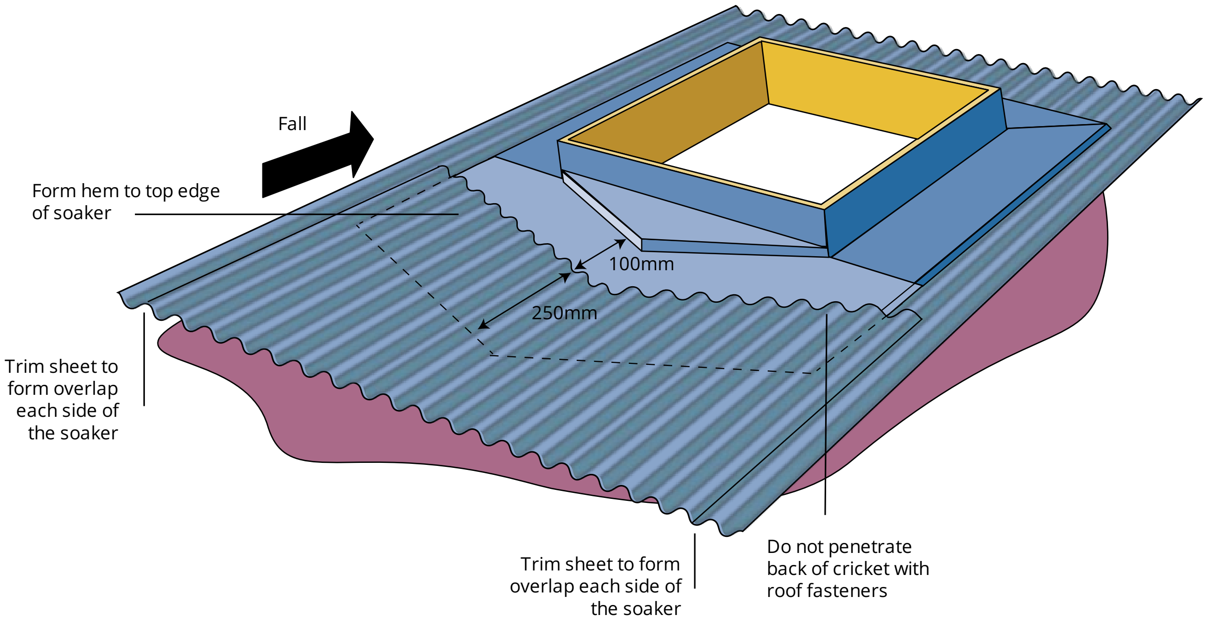
## 9.5.5G Level Soaker Flashing on Corrugated Profile



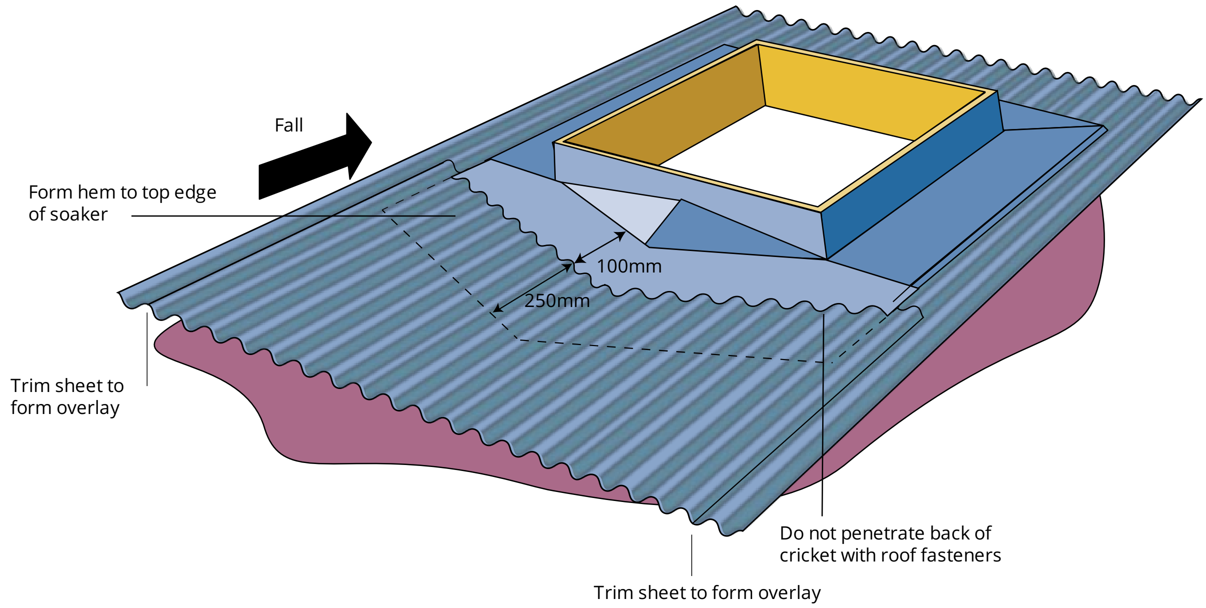

## 9.5.5H Level Soaker Flashing on Trapezoidal Profile



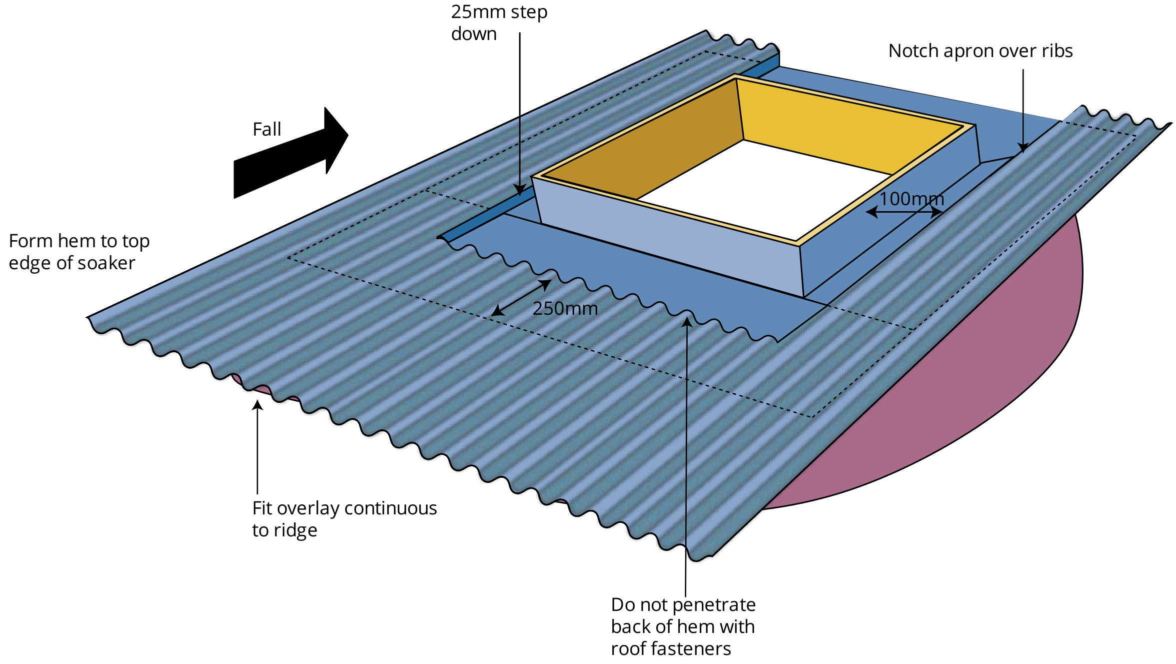
## 9.5.5I Arrow Head Soaker Flashing on Corrugate Profile




## 9.5.5J Cricket Soaker Flashing on Corrugate



## 9.5.5K Level Hidden Gutter on Corrugated Profile



# 9.6 Boot Flashings

A boot flashing is a proprietary EPDM flashing designed to weatherproof cylindrical penetrations protruding from a roof or wall. The top is trimmed to form a tight weatherproof collar around the penetration, and the base is formed with a series of concentric rings to the underside and a malleable stiffener of aluminium which is dressed to conform to the shape of the roofing profile. It is generally top-fixed to the roof surface with screws or rivets, and sealant.

The Profiled Metal Roofing COP allows pipe penetration flashings to be fitted directly to the profile or on to an over flashing. Pitch limitations depend on the method used and the cladding profile.

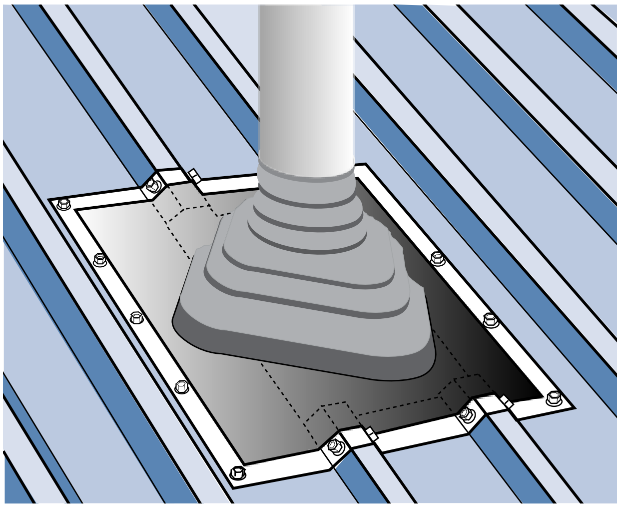
Direct-fixed options are pitch sensitive. When laid directly on to the profile at too low a pitch, they will entrap water rather than allow it to discharge over the profile crests that they traverse. The practical limits of direct-fixed boot flashings that cross an entire pan are 8° for standard corrugated and 10° for low rib trapezoidal products. Where the base of a boot does not obstruct a pan it can be direct-fixed to the minimum pitch for that profile.

Direct fixed applications for high rib trapezoidal profiles and trough sections vary according to the profile, and the size and position of the penetration. For these applications, the manufacturer should be consulted or the flashing can be attached to an over flashing, or a top fixed soaker type can be used.

Where the penetration is wide such as a chimney flue casing, and the penetration is far from the apex, soaker flashings may be used where the profile ribs are cut back so water can divert into the adjacent pan.

Where overall width is not a constraint, directly fixed boot flashings should be installed with their edges diagonal to the fall of water. Where this is not practical, they may be laid square at pitches of 10° or more.

## 9.6A Square-Fixed Over-Fitted Boot

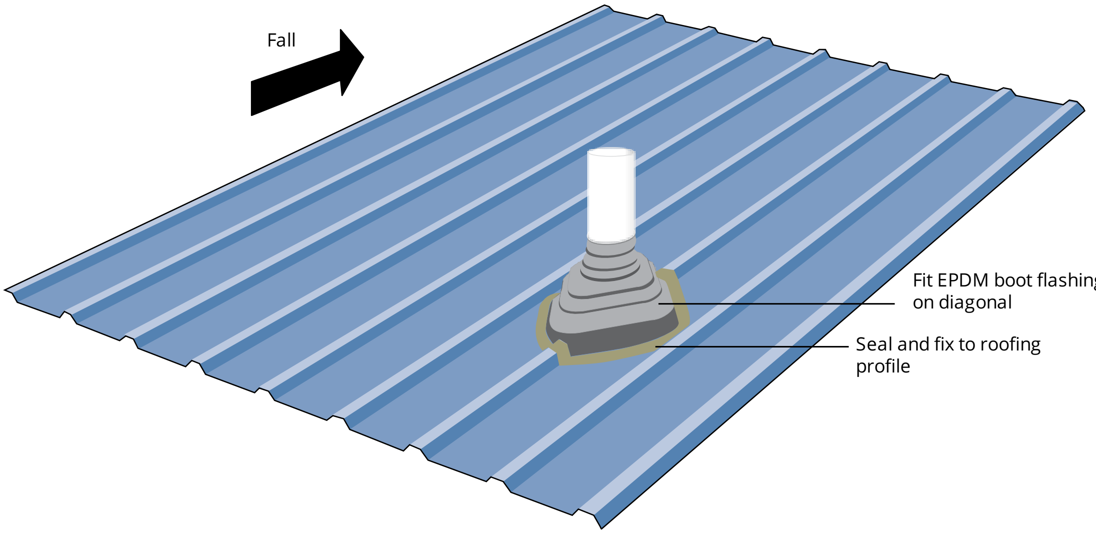


Where boot flashings traverse a lap, the lap must be fully sealed or other actions must be taken to avoid leaks through capillary action. Where possible the fixing of a boot flashing over a lap should be avoided

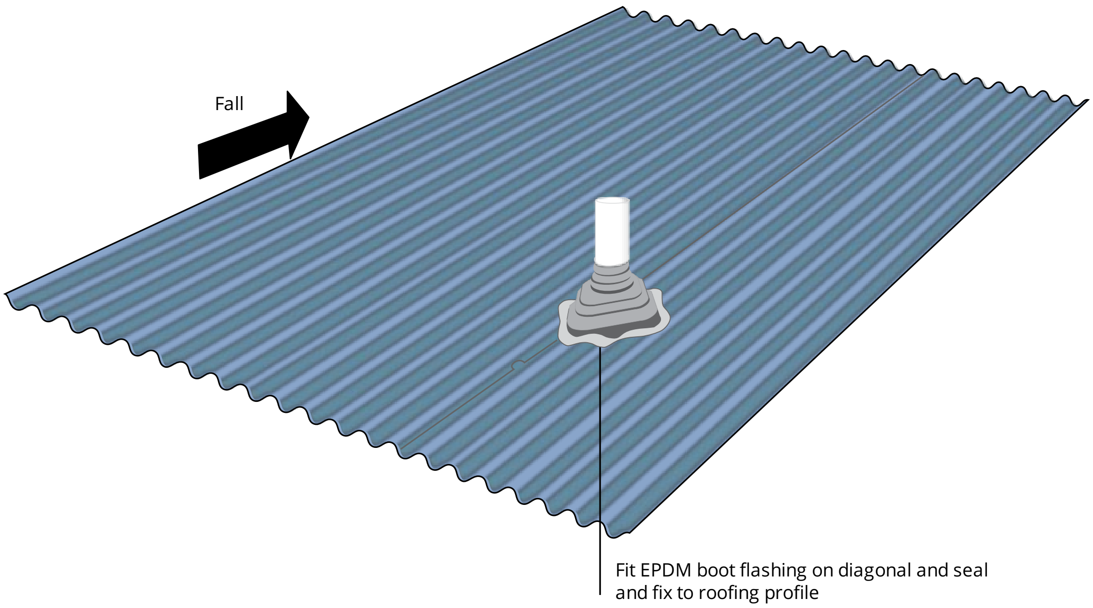
 

The vertical sections of a boot flashing must not constrict the free flow of water. Where more than 50% blockage of the pan occurs other penetrations must be considered, or catchment calculations of the capacity of the remaining pan area should be made. (See 5.3.2 Capacity Calculations)

## 9.6B Direct-fixed Boot on Trapezoidal Profile




## 9.6C Direct-fixed boot on Corrugated Profile

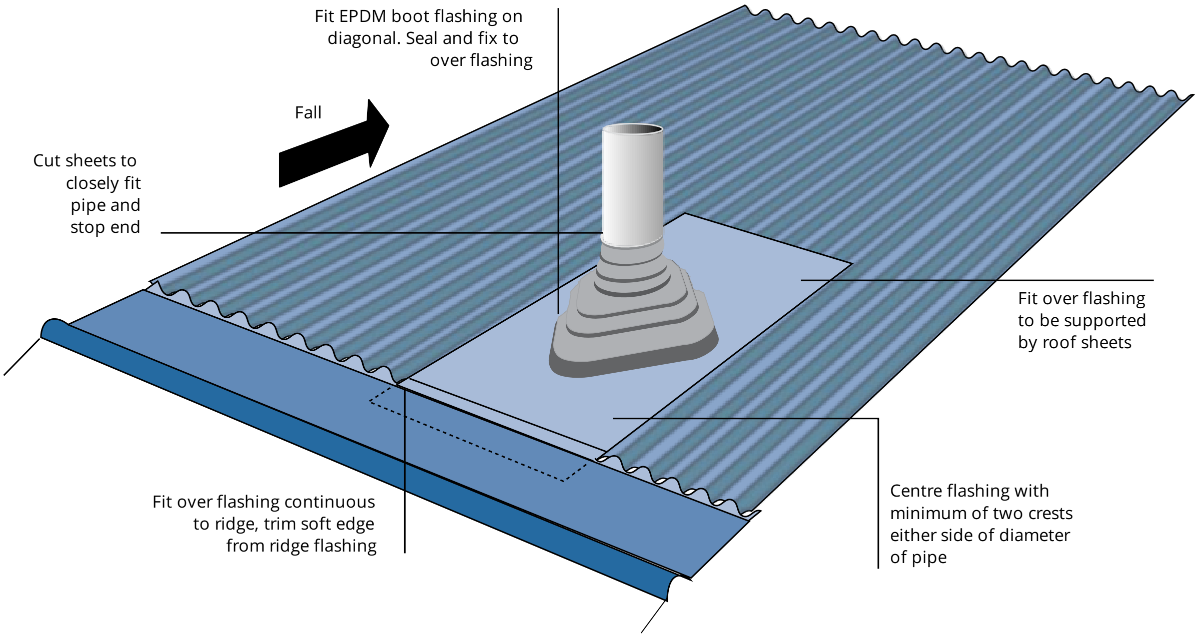



## 9.6.1 Boot Flashings to an Over Flashing

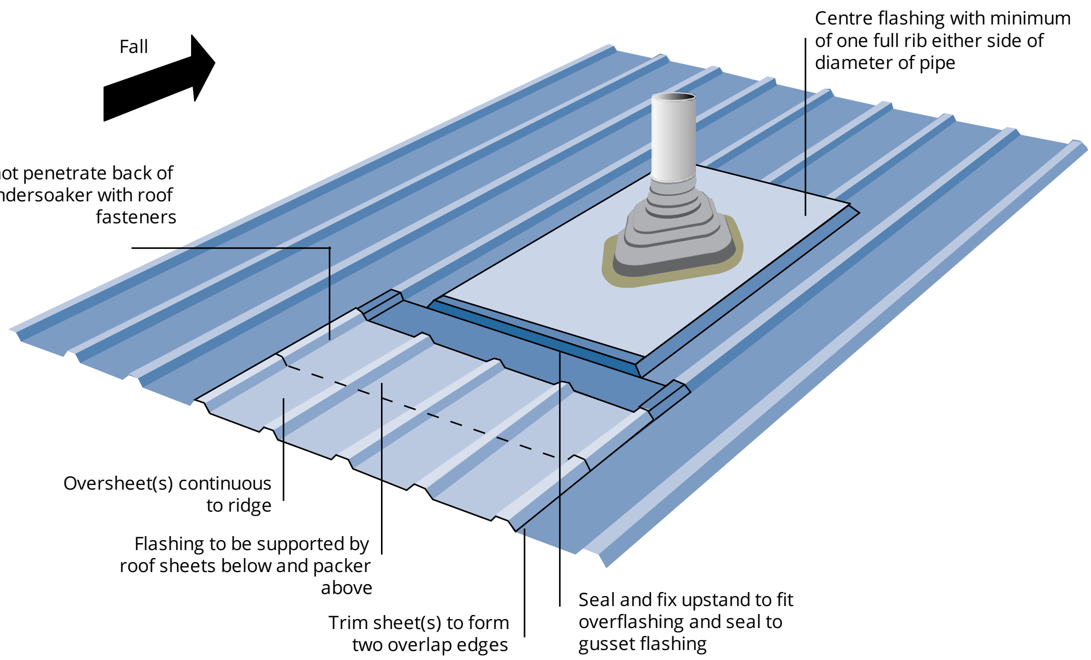
Boot flashings fitted to an over flashing are acceptable at pitches down to the minimum of that allowed for the profile. Typically, this is 8° for standard corrugated, and 3° for trapezoidal and trough sections. These boot flashings must be fixed diagonally to the fall of the roof at pitches below 10°.

Over flashings can be continuous to the apex, or terminate with a soaker at the upper edge.

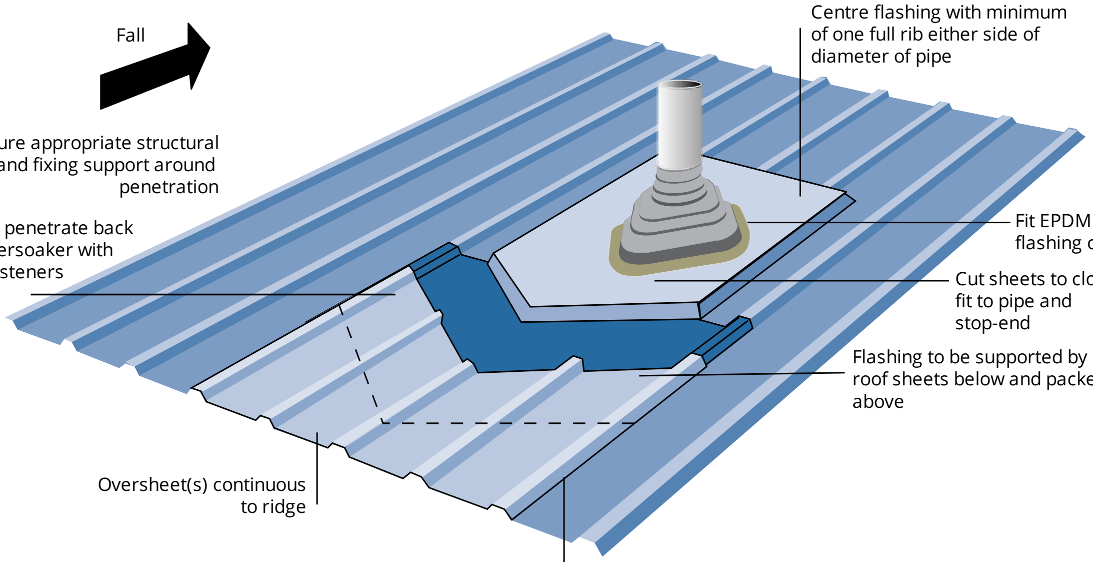
## 9.6.1A Over-Flashed Boot Flashing on Corrugated Profile




## 9.6.1B Over-flashed Boot with Soaker Level Curb on Trapezoidal Profile



### 9.6.1C Over-flashed Boot with Arrowhead Soaker on Trapezoidal Profile



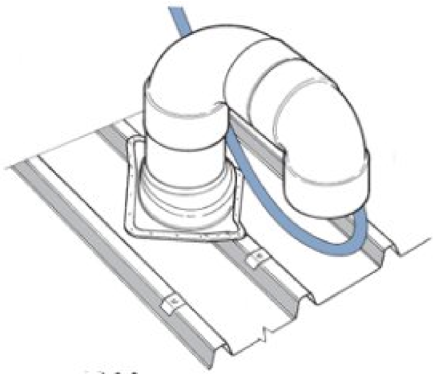

## 9.6.2 Other Applications for Boot Flashings

### 9.6.2.1 Plant Room And Conduit Penetrations

Where flexible power conduits or telecommunication cables are required to penetrate the roof cladding, accessibility can be improved by using P.V.C pipe fittings and an E.P.D.M. flashing to weather a number of conduits.

Cable penetration flashings must be goose-necked. It is not acceptable to exit cables through a vertical flashing such as a boot flashing where sealant is the only barrier to water leakage.

### 9.6.2.1A PVC and E.P.D.M Flashing



*This flashing should be fixed next to the purlin for support.*

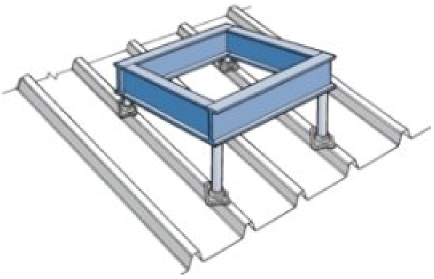
Safety bollards for fall arrest anchorages are required where regular maintenance is required, and these can also be weathered by E.P.D.M. flashings.

## 9.6.2.2 Mechanical Services

Where plant room supports are required to penetrate the roof cladding, the designer should provide the support framing from Circular Hollow Sections (CHS) in preference to Rectangular Hollow Sections (RHS) or other hot rolled steel sections, because it is easy to flash the CRS with E.P.D.M. flashings. This procedure allows the E.P.D.M. flashings to be slid over the pipe framing during erection, and avoid the necessity of using retrofitting types.

The support framing should be in place, but below the top of the purlin, before installing the roof cladding. That allows the cladding installation to proceed without having to weatherproof multiple penetrations at the same time.

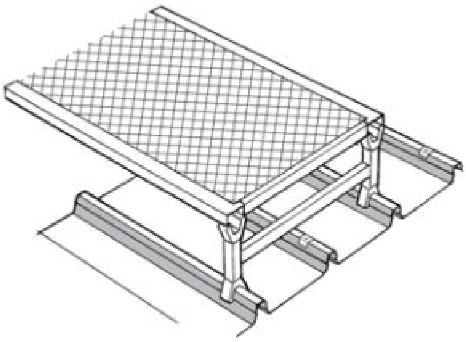
### 9.6.2.2A Support Framing



(optional caption)

Proprietary support systems are available for lightweight support through to the purlins.

### 9.6.2.2B Lightweight Support Frame



These types of supports provide clearance for cleaning but should not create an unwashed area underneath them.

## 9.6.3 Flush Penetrations

Penetrations such as roof window may be mounted flush with the crests of the roofing profile.  In such cases, the side flashing onto the roof shall be the same as required for a barge cover. The flashing termination onto the roof window shall be as per window manufacturers requirements

# 10 Roof Ventilation

The science of internal moisture control is concerned with the need to manage and control condensation.
The condition of the outside environment, the building design, and occupant behaviour affect humidity in the living spaces, which ultimately affects humidity in the ceiling space.
This section of the COP focusses predominantly on managing humidity in the ceiling space of dwellings.
Shorter sections also cover the design of wall cladding. Non-residential roof and wall cladding may be affected by the need to control internal moisture.

## 10.1 NZBC Clause E3 Internal Moisture.

New Zealand Building Code clause E3 – Internal Moisture, and G4 – Ventilation, both focus on air quality in occupied spaces. The NZBC does not specifically require the ventilation of attic spaces.

While problems with excessive internal moisture in attic spaces are relatively uncommon, they can be severe. A poorly designed ceiling cavity, even above a well-aired room, can give rise to internal moisture problems in the attic space, which can affect the air quality of the occupied space below and may cause health and durability issues.

The COP recommends using building techniques which encourage trickle ventilation of all spaces in buildings and requires specific ventilation design for flat roofs, sarked roofs, skillion roofs, and roofs with open ceilings.

Roofs in cold areas where numbers of people may come in wet at the end of the day, such as ski lodges and tramping huts, also require specific design.

Generally, there is no need to make provision for moisture control in industrial and most commercial buildings. Buildings designed to accommodate large numbers of people such as theatres, sports areas and educational buildings, and areas creating particularly high moisture levels—e.g., swimming pools—should have ventilation solutions designed by a specialist engineer.

### 10.1A NZBC Clause E3 — summary

**Objective:**

Safeguard people against illness, injury, or loss of amenity that could result from the accumulation of internal moisture.

**Functional Requirements:**

Buildings must be constructed in a way that avoids damage to building elements due to the presence of moisture.

**Performance Requirements:**

NZBC Clause E3 requires building practices to ensure an adequate combination of thermal resistance, ventilation, and space temperature in all habitable spaces, bathrooms, laundries and other spaces where moisture may be generated or accumulate.

*Source: Acceptable Solutions and Verifications for New Zealand Building Clause E3 Internal moisture.*

## 10.2 Condensation

The primary purpose of the roof cladding is to act as a rain screen so that no water enters the building from the outside. It is, however, equally important to ensure that the building is kept dry from within. Because metal roof and wall cladding are good heat conductors and are not absorbent, condensation forms on metal cladding under conditions of high humidity or changes in temperature.

Water is present in or on the surface of most building materials. Roofing materials are designed to tolerate a certain degree of dampness, and can also withstand greater wetness for short time spans. Excessive and prolonged wetness, however, can reduce the durability of most building materials, and cause the formation of health-threatening mould.

In gas form, the kinetic energy of the molecules overcome the bonds of attraction. This is why water vapour has a strong tendency to migrate upwards into the ceiling cavities, and why it is so important to manage the atmospheric conditions in attic spaces.

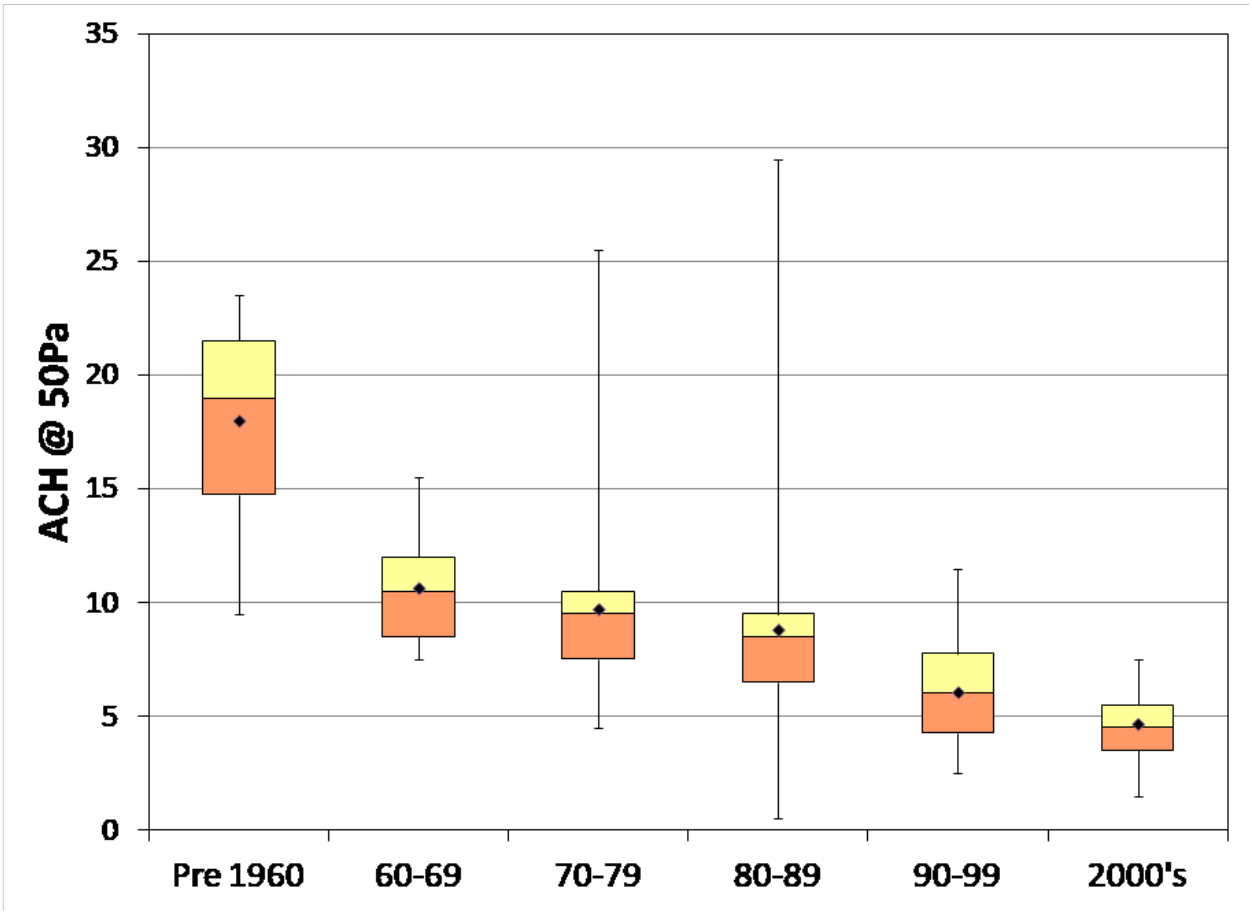
Water vapour tends to condense into liquid form when the concentration rises or the temperature drops. Condensation occurs readily when the humidity is high. At a relative humidity of 95% and a temperature of 20°C, only 1°C difference in temperature is required before dewpoint is reached; at 50% relative humidity this difference is 11°C.

The ratio of the mass of water suspended in vapour form compared to the value that saturated air could contain is known as 'Relative Humidity' and expressed as a percentage. The point at which air can hold no more water is called the 'Dew Point' or saturation point and equals 100 % relative humidity.

## 10.3 Building Airtightness

Changing building techniques and materials—e.g., the increasing use of insulation, impervious cladding, and aluminium joinery—have led to buildings being much more airtight.
Occupant behaviour has also changed. More families shower daily and then leave the house unoccupied and closed-up for much of the day and night. Less activity means a low level of air changes per hour. These changes can lead to internal moisture problems.

### 10.3A BRANZ Survey showing changes in permeability on NZ houses over time




To ensure that the installation of the roof or wall cladding does not cause moisture problems within the structure, neither the roof designer and the roof or wall cladding contractor should create conditions that could jeopardise the durability of the cladding or the structure.

## 10.4 The External Environment

The external environment that affects roof ventilation includes:

- The Climate.
- Water

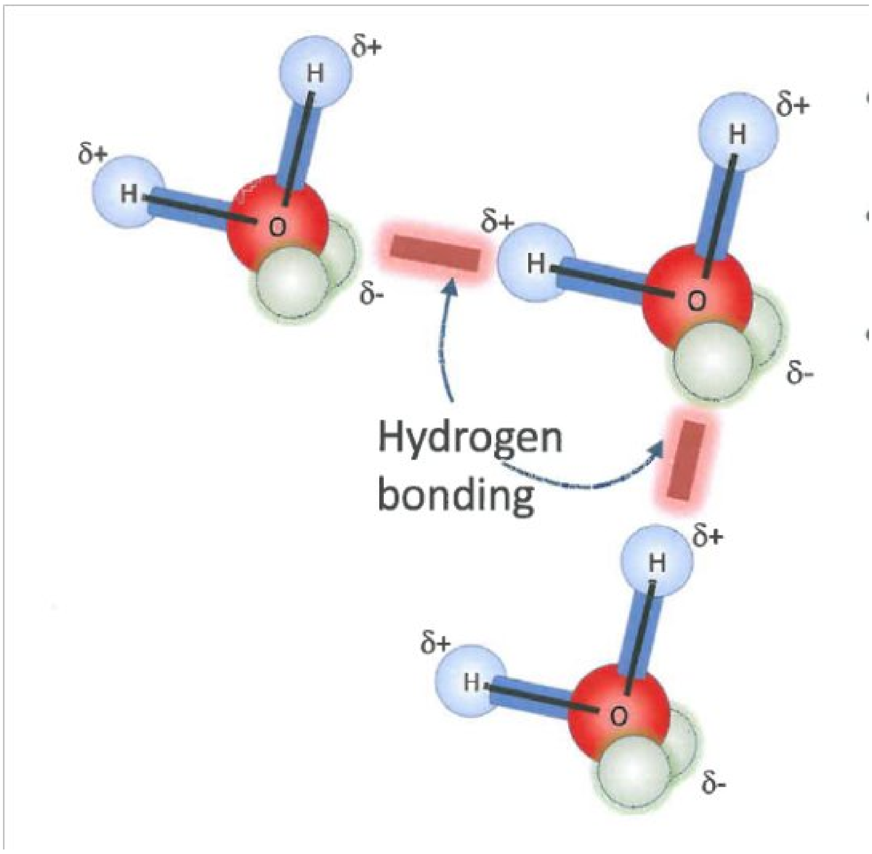
### 10.4.1 Climate

Being narrow, mountainous islands lying in the path of the prevailing wind, New Zealand is subject to high rainfall and high humidity.
Compared to much of the world where 70% humidity is considered to be the threshold of corrosion and health problems, New Zealand has very high humidity, particularly around the northern regions, where the relative humidity is often more than 90%.
Temperature variations, on the other hand, are quite low; nearly all the inhabited areas of NZ being in what is defined as a Temperate environment.
The design requirements to deal with this environment are specific to NZ's climate and building practices. It is not advisable to use design or installation practices from countries with different environmental conditions, without comprehensive assessment.

### 10.4.2 Water

Water exists in 3 states: solid (ice), liquid (water), and gas (water vapour). Water in liquid form is relatively dense, and ice slightly less so. This is largely due to attraction the molecules have to each other. The molecular attracton makies water form droplets on a surface.

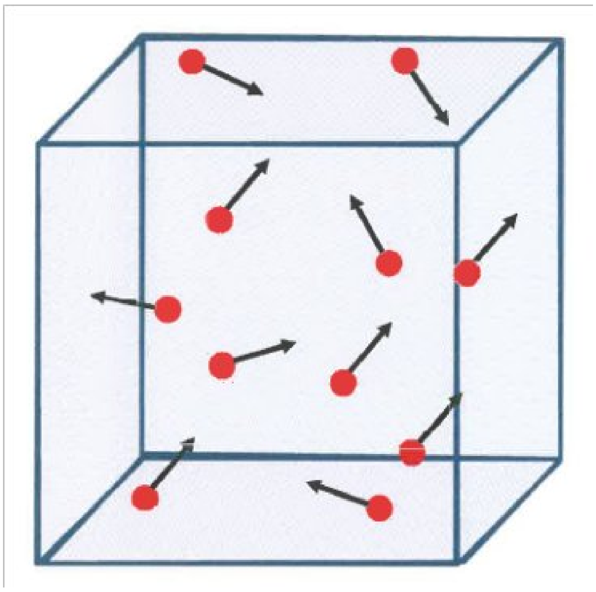
## 10.4.2A Hydrogen Bonding




*Water molecules in liquid form bonds which create a dense material.*

In vapour form, water molecules do not have this bonding. Water Vapour is very light compared to other gasses in the atmosphere, which is 78% nitrogen.

## 10.4.2B Water Vapour



The kinetic energy of water molecules in gas form creates space between the molecules.

## 10.4.2C Shower Condensation

*The high humidity created while showering causes condensation on even relatively warm surfaces because of the high concentration of vapour.*

## 10.4.2D Condensation on a Cold Glass

*In warm conditions, condensation will form on a cold surface, even when the concentration of water vapour in the atmosphere is low.*

# 10.5 The Living Environment

## 10.5.1 Cold Roofs

In Cold Roof construction the insulation is at ceiling level, and there is an air gap between the insulation and the roof surface.
With cold roof construction, the under-surface of the metal roofing will at times be quite low, so the primary tool of managing condensation is to control the concentration of water vapour in the attic space.
As some condensation is inevitable, this must be managed to ensure it is not excessive in terms of degree or duration.

## 10.5.2 Warm Roofs

In cold places such as Europe and Northern USA where heated buildings are the norm, air is 'conditioned' to control the humidity and keep the heat in. In hot countries where the emphasis is on cooling, insulation and vapour barriers are used to keep the heat and moisture out.
Buildings in hot countries are typically constructed with a warm roof. The insulation is in direct contact with the underside of the roof, and a vapour-control layer is installed on the underside of the insulation to limit moisture infiltration to the underside of the roof. These systems require careful design and engineering and are, therefore, marketed as proprietary systems. See 15.5 Insulated Panels.

## 10.5.3 Managing Water Vapour at the Source

Bathing and showering, cooking, heating, and clothes drying are the most obvious sources of water, but respiration, perspiration, indoor plants, and pets all produce moisture.
Areas of moisture-generating activities should be well ventilated, and preferably mechanically ventilated to outside the structure.
Some other sources of moisture are best avoided altogether, particularly unvented gas heating and kerosene heaters. Burning 1 kg of gas can release 1.6 L of moisture into the atmosphere.
Occupant behaviour is another large variable which is difficult to manage or predict.
The COP recommends opening a window when possible, and have security stays so that some ventilation can be maintained throughout the day.

## 10.5.4 Construction Moisture

During construction, timber can become wet and take some time to dry out. Activities such as plastering and painting also release water vapour.
Concrete floors are a particularly prolific source of moisture. During curing, a 100 mm thick concrete slab

releases approximately 10 L of water vapour per square metre of surface area. The period over which this occurs varies, but a rule of thumb is that a concrete floor cures at the rate of 25 mm per month, therefore a concrete slab can affect internal moisture levels for a considerable period.
All new buildings, particularly those with concrete floors, must be kept well ventilated until moisture levels of construction materials have stabilised.

### 10.5.4A Mould Damage

*This building suffered mould damage to underlay and roof truss even before occupants moved in.*

## 10.5.5
## Controlling vapour migration into the ceiling space

A gloss painted plasterboard ceiling presents some resistance to the passage of water vapour but is not a complete barrier. Vapour will also find its way through any minor gaps in architraves and other timber trimmings. Ceiling tiles and tongue and groove ceilings generally have a greater porosity than plasterboard.
Unsealed downlights can be a major source of moisture traffic into the ceiling cavity and should be avoided where possible. Alternatively, replace them with sealed lighting units or the install roof space ventilation.
Wall cavities must be closed off at the top so that they do not transmit vapour from groundwater to the ceiling space
With low energy housing, proprietary systems can be used which limit the amount of air movement through the ceilings. These systems can be very effective if used systematically, but the COP does not recommend using impervious vapour barriers in an ad hoc manner as an alternative to roof space ventilation. If more water enters the ceiling cavity than the evaporation rate, chronic moisture problems will occur.

### 10.5.5A Managing water vapour within the ceiling cavity—Residential

Apart from a low energy house with a sealed envelope or a roof with complete ventilation, the humidity in the ceiling cavity will mostly be greater than that of the surrounding atmosphere. It may also be colder at night due to 10.5.6 Night Sky Radiation.

## 10.5.6 Night Sky Radiation

*Roof cladding absorbs radiation from the sun and the attic space becomes warmer, and some of this heat is radiated at night into a clear night sky.*
*Because all objects radiate heat to cooler objects, night sky radiation will occur when there are no clouds in the sky, at a rate dependent upon the emittance of the roof cladding.*
*Radiation to the sky can cause the cladding temperature to drop as much as 5˚C below that of the surrounding air and this will produce dew when the dew point is reached, or frost if the temperature falls below zero.*

## 10.6 Ventilation

The first line of defence against excessive roof space moisture is to restrict water egress by good design and rational occupant behaviour. The second is by ventilating the ceiling cavity.

Barriers to the natural airflow in the ceiling cavity must be avoided. These barriers include non-perforated profiled filler strips at the eaves and apex, and insulation pushed up hard against the underside of the roofing material.

Underlay should terminate at the ridge purlin, or have strips or slots cut in it where it traverses the apex; this alone can double air changes in the ceiling cavity.

Moisture saturation points are easily reached in skillion and flat roofs, even with normal moisture levels, because of the small air cavities. Such roofs and any other high-risk designs must be ventilated to comply with the NZMRM Code of Practice.

Other high-risk situations include skillion or curved roofs in which the ceiling line follows the roof cladding, so the air volume is significantly reduced, or curved or tight capped roofs where there is little or no ventilation at the apex.

Additional ventilation mechanisms include:

- Louvre vents in gable ends.
- Soffit vents.
- Fascia vents.
- Proprietary ridge vents.
- Ventilated soft edge strips on transverse flashings.
- Solar powered or wind-powered vents positioned close to the apex.

Where eave vent intake and ridge vent exits are both employed, the area of the ridge vents should be less than that of the eave vents. This arrangement prevents air escaping through the ridge vent from lowering the pressure of the attic cavity, which will encourage more ingress of moist air from the dwelling area.

For venting to be effective, an intake at the lower edge and outlet at the upper edge of the roof end is optimal. In pitches of 30° or less, cross venting alone is generally sufficient, combined with trickle ventilation at the ridge or apex.

When ventilated ridges are used, the underlay must be terminated at the ridge purlin to allow free passage of air. The COP recommends that the underlay is terminated at the ridge, or slit or slotted to allow passive ventilation of the ceiling cavity.

While a rule of thumb of 1/300 of ventilation aperture to ceiling area exists overseas, far smaller ratios have proven sufficient in NZ conditions. The main rule is to let air in at the bottom, out at the top, and provide a free passage in between.

The function of bulk insulation is to trap air, so the effect of moderate air movement is insignificant. Wet insulation, however, is ineffective. Ventilation of spaces above insulation to remove excess moisture will allow the insulation to perform to its design capacity.

When insulation fills a ceiling cavity or takes up a significant portion of the ceiling cavity space, it inhibits ventilation. The installation of a vapour barrier to limit entry of moist air into the ceiling space has been used in some older New Zealand homes, but removing damp air by ventilation is a more practical approach unless a properly engineered vapour control system is adopted.

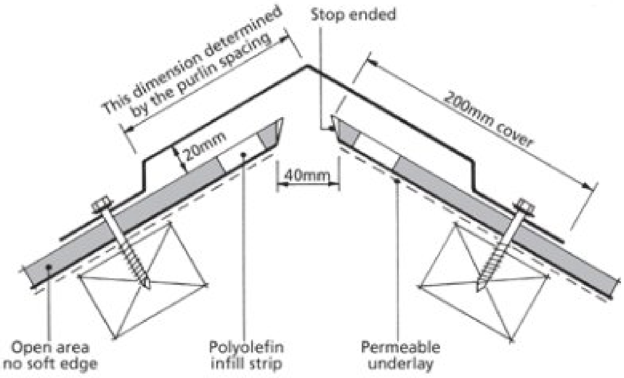
A minimum air gap of 20 mm must be provided between bulk insulation and the roof.

Even with good ventilation, condensation may form at times on the underside of the roof and, more commonly, on the underside of the underlay. This is acceptable, providing the quantity of condensation, and the duration of it being present is not excessive.

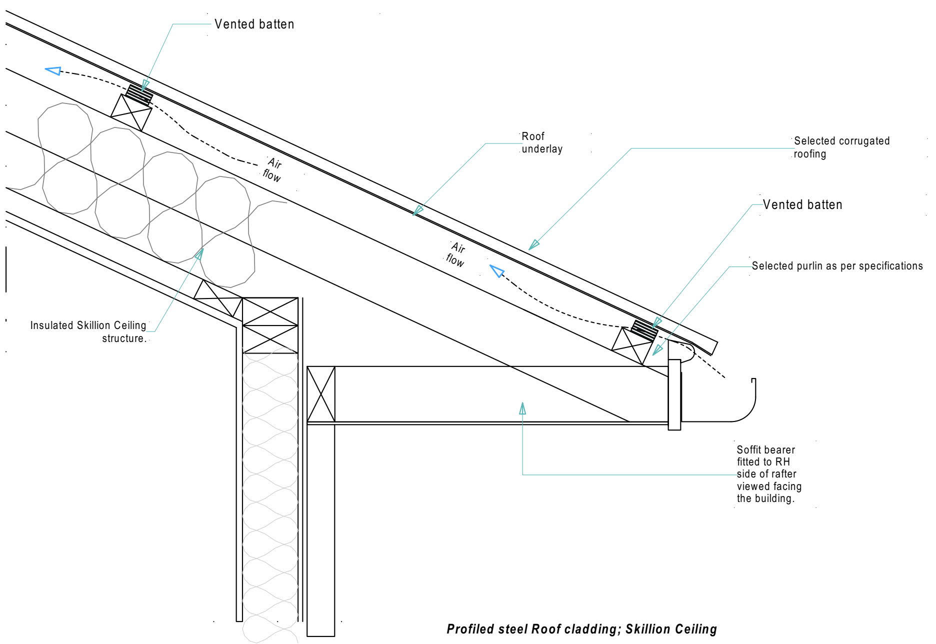
## 10.6.1 Natural Ventilation

### 10.6.1A Ridge Vent

## 10.6.1B Ridge Vent Details



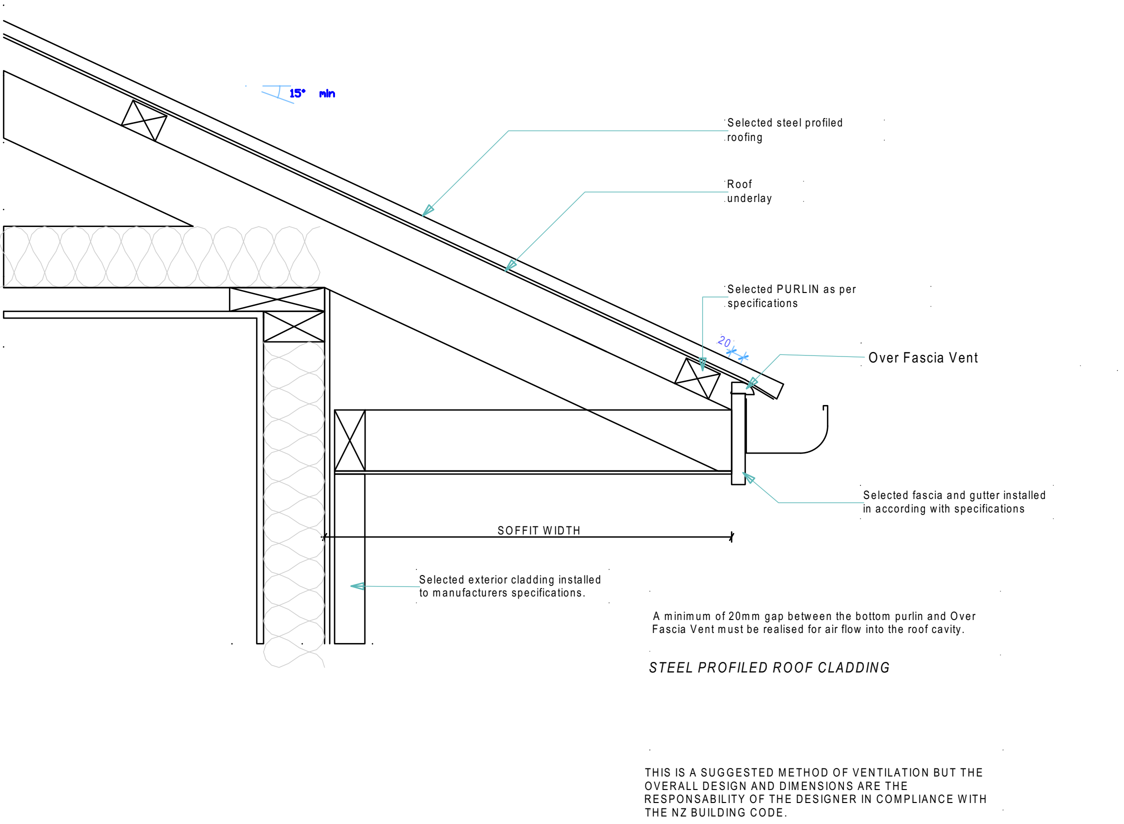

## 10.6.1C Vented Batten



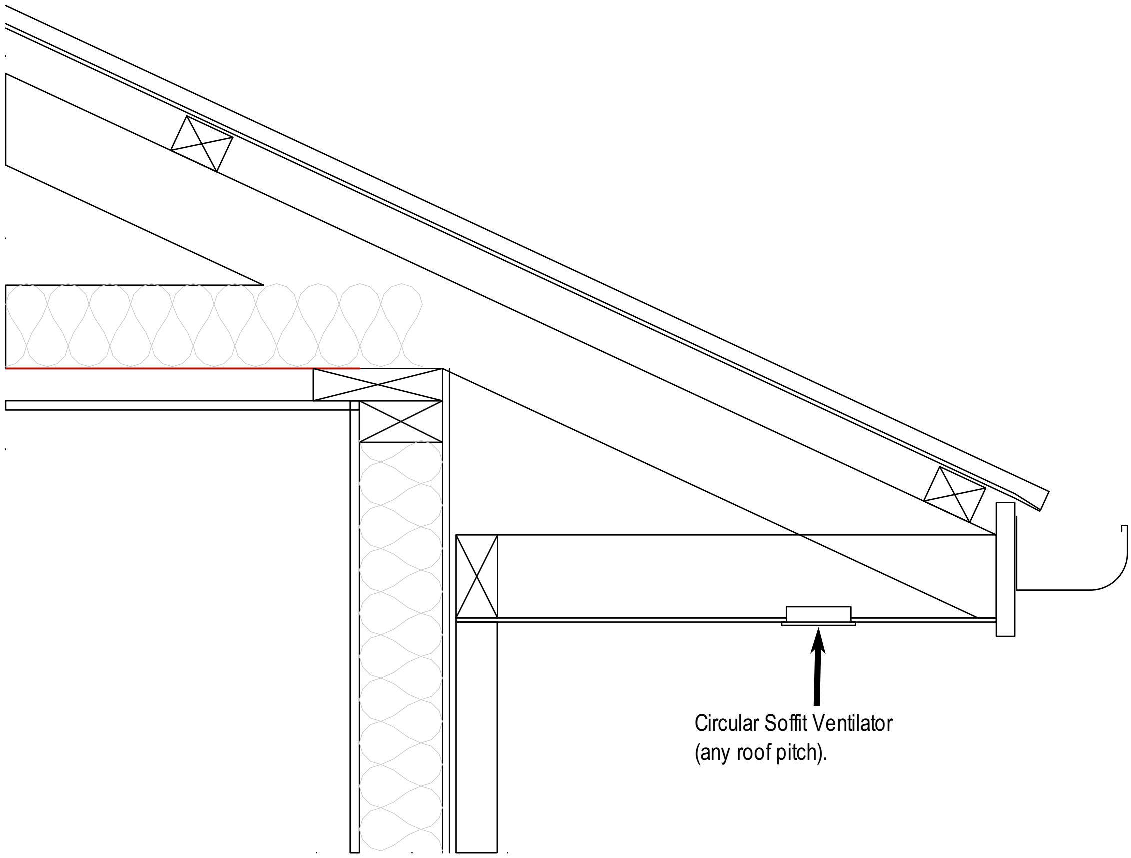

***Profiled steel Roof cladding; Skillion Ceiling***

THIS IS A SUGGESTED METHOD OF VENTILATION BUT THE OVERALL DESIGN AND DIMENSIONS ARE THE RESPONSABILITY OF THE DESIGNER IN COMPLIANCE WITH THE NZ BUILDING CODE.

## 10.6.1D Over Fascia Vent

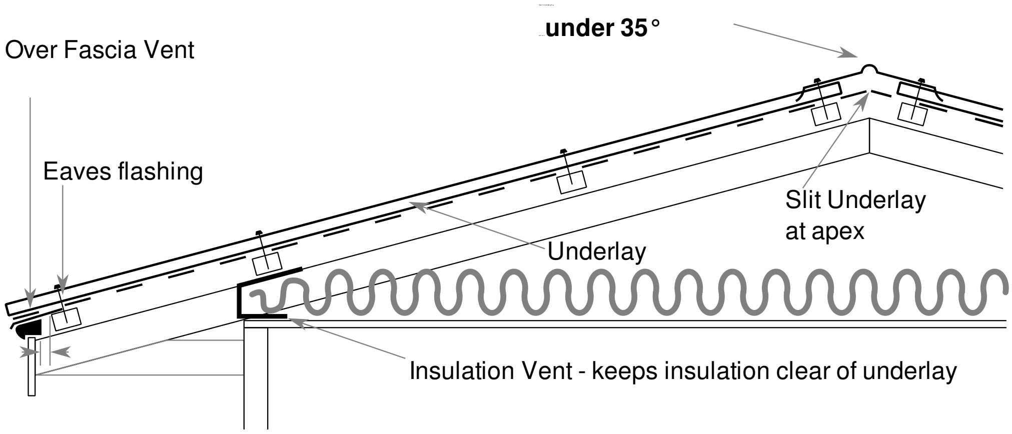


## 10.6.1E Circular Soffit Vent

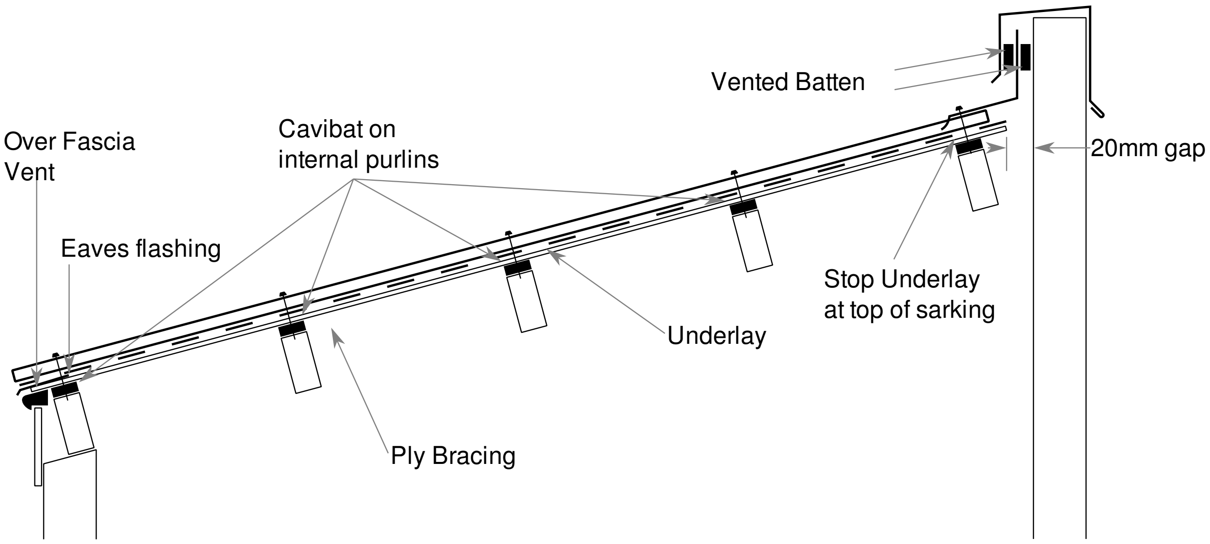



THIS IS A SUGGESTED METHOD OF VENTILATION BUT THE OVERALL DESIGN AND DIMENSIONS ARE THERESPONSABILITY OF THE DESIGNER IN COMPLIANCE WITHTHE NZ BUILDING CODE.

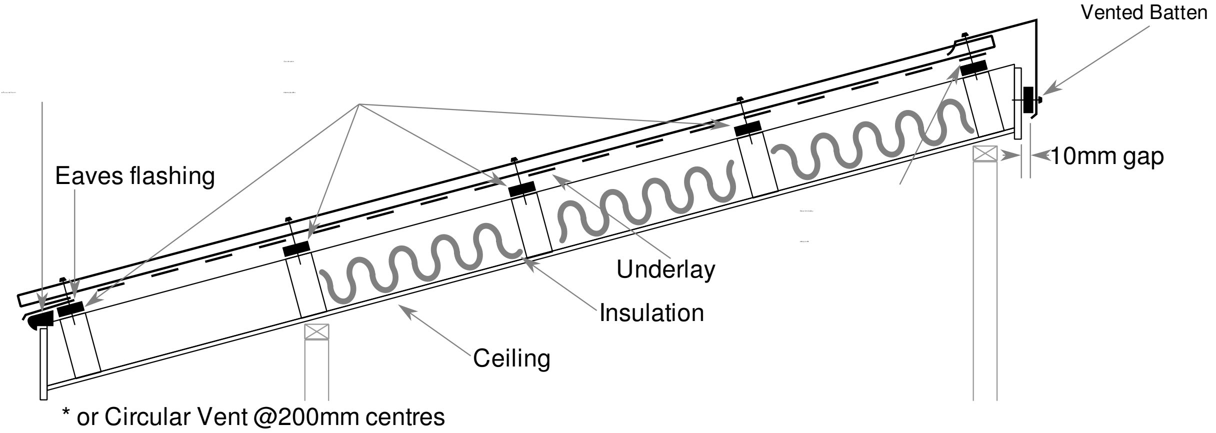
## 10.6.1F Typical Truss Roof




## 10.6.1G Sarked Mono Pitch to Parapet



## 10.6.1H Skillion Mono Pitch — Full Height Purlin




## 10.6.2 Commercial Ridge Vents

Permanent ventilation of the roof cavity may be achieved by using accessories such as gable louvre-ventilators, purpose-made ventilators, wind or powered extractors, or by using a vented ridge.

Continuous ridge vents used in conjunction with eave inlets can provide the necessary air movement to avoid the accumulation of condensation Their efficiency depend on the wind direction, because there is positive pressure on the windward side, and negative pressure on the leeward when the wind blows 90° to the ridge.

To be thoroughly efficient, the inlet area should larger than the outlet area. Because fluctuations in air pressure can vary from positive to negative along a section of vented ridge under gusty wind conditions, the lack of a sufficient inlet area can also promote leakage of ridge vents.

The lower down the building height the inlets are, the more efficient the ventilation will be. The steeper the pitch, the greater the stack effect and the better the air flow.

In very exposed areas, high winds may cause excessive air movement

## 10.6.3 Turbine Vents

Rotary ventilators are generally preferable to ridge ventilators for commercial roofs.

They are more weathertight, perform well in all wind conditions, have a determinable airflow capacity, can readily be damped when airflow is not required, and can be retrofitted if more ventilation is required.

### 10.6.3A Turbine Ventilator

Rotary ventilators should be positioned as close to the apex as possible, at spacings of up to 6 metres apart. As with all forms of ventilation, they work most efficiently when there is ample air intake capacity at a lower level.

Capacities and air change calculations vary with design and can be obtained from the supplier. Common sizes range from 150 mm to 900 mm throat size.

## 10.6.4 Mechanical Vents

Supply-driven and exhaust-driven mechanical ventilation systems can pressurise or depressurise internal atmospheres in different areas of the building interior, and need to be well designed and maintained to avoid the risk of them affecting internal moisture.

A balanced mechanical ventilation system where both intake and exhaust is to the outside atmosphere is preferred. Mechanical vents need specific design.

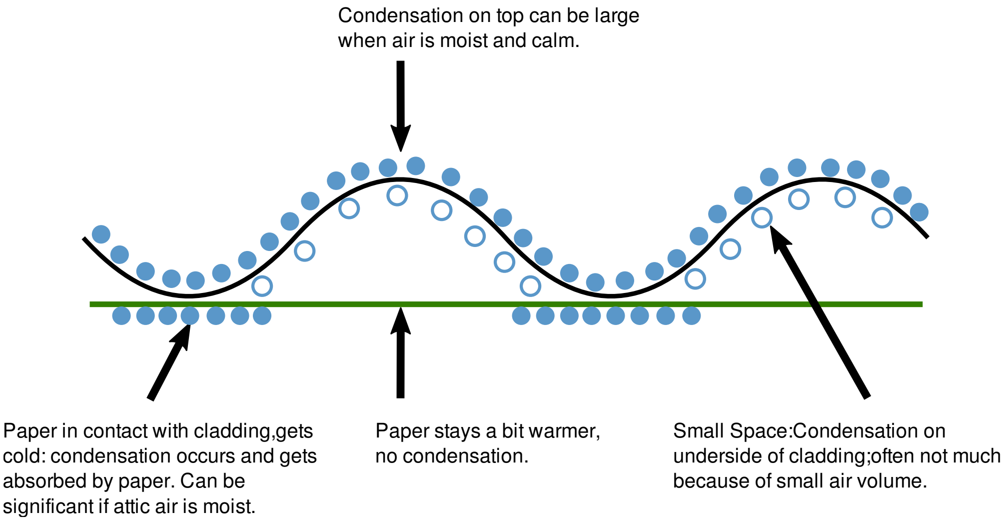
# 10.7 Underlay

Condensation that forms on the cold under-surface of the roof system must be contained until it can evaporate. This is normally achieved by using an absorbent roofing underlay.

It is a common misconception that the function of a roof underlay is to act as a drainage plane to channel water condensing on the underside of the metal roof to the gutter. Most condensation forms on the underside of the underlay, because while roofing underlays are permeable they still form a substantial vapour check, and as they are in contact with the roof they are at a similar temperature.

Underlay is also affected by holes from roofing fasteners.

## 10.7A Roof Cavity Condensation



## 10.7B Condensation on Underlay

## 10.7C Condensation on Synthetic Underlay

## 10.7.1 Types Of Underlay

An underlay under metal roof cladding on residential buildings must be Vapour permeable and absorbent. It may be one of two types:

- Kraft paper-based, permeable, both bitumen-impregnated or non-bituminous. These are generally absorbent.
- Synthetic, permeable complying with the requirements in 10.7.1A Properties of Permeable Roofing Underlays. These may be absorbent or non-absorbent.

Permeable underlays should comply with NZS 2295, Amendment 1:2017 as shown in 10.7.1A Properties of Permeable Roofing Underlays
Minimum requirements for underlays for the metal roofing industry are as follows:

- NZS 2295 classifies underlays by their use in roofs or walls.
- Those that are suitable for metal roof and wall cladding are Roofs R1 and R3 (heavy) and R2 and R4 (self-supporting), Walls W2 (heavy) and W4 (synthetic)

### 10.7.1A Properties of Permeable Roofing Underlays

| **Classification** | | **R1** | **R3** | **R2** | **R4** |
|---|---|---|---|---|---|
| **Grade** | | Heavy weight | Heavy weight | Self support | Self support |
| **Type** | | Kraft | Synthetic | Kraft | Synthetic |
| **Application** | | | Residential or light commercial buildings | | |
| **Property** | **Unit** | | | | |
| Absorbency | g/m² | ≥ 150 | ≥ 150 | ≥ 150 | ≥ 150 |
| Water Vapour Resistance | MN s/g | ≤ 7 | ≤ 0.5 | ≤ 7 | ≤ 0.5 |
| Water resistance | mm head | ≥ 100 | ≥ 100 | ≥ 100 | ≥ 100 |
| Tensile Strength MD | KN/m | ≥ 9 | ≥ 3 | ≥ 11 | ≥ 3 |
| Tensile Strength CD | KN/m | ≥ 4.5 | ≥ 2 | ≥ 6 | ≥ 2.5 |
| Edge Tear Resistance MD | N | ≥ 40 | ≥ 100 | ≥ 70 | ≥ 150 |
| **Edge Tear Resistance CD** | N | ≥ 35 | ≥ 80 | ≥ 55 | ≥ 130 |

*Based on Table B1 of NZS 2295 Amendment 1:2017.*

- *Self-supporting (S/S) is defined as strong enough to support its own weight up to a 1200mm span.*
- *pH between 5.5 and 80.*
- *Kraft based underlays shall have shrinkage less than 0.5% and maximum run-length of 10 m.*
- *Synthetic underlays may have any length of run.*
- *Any underlay is regarded as Fire retardant if it has a FI (Flammability Index) of 5 or less when tested to AS/NZS 1530 Part 2.*

## 10.7.2 Underlay Usage

Absorbent vapour permeable underlays must be used under profiled metal roofs and direct-fixed metal cladding on lined buildings, non-absorbent permeable underlays can be used on a drained wall cavity.

## 10.7.3 Underlay Durability

With normal maintenance, metal cladding can last 50 years or more and the "hard-to-replace" elements beneath it should have the same durability. That also applies to support materials, such as netting, safety mesh or plastic strapping. Netting and mesh are available with plastic coating for use in severe environments.

## 10.7.4 Installing Underlay

### 10.7.4.1 Direction of Lay

Horizontally laid underlay must be supported, while vertically laid underlay can be self-supported if purlin spacings allow.  Roof and wall underlay can generally be laid either horizontally or vertically.  However, on pitches of less than 10°, E2/AS1 requires underlay to be laid horizontally on support. Horizontal underlay must be laid starting at the lowest point of the roof, running over the bottom purlin. Subsequent layers must be lapped over the lower layer to ensure water is shed to the outside face of the underlay.

Underlay for roof cladding must have a minimum side and end lap of 150 mm.

The lower end of underlay may terminate on the outside of the fascia line, or overshoot it by a small margin. Underlay should not overhang the fascia to the extent that it can wick up moisture from the spouting. In most situations, the overhang should not exceed 20 mm.

Flue penetrations must have a minimum distance of 50 mm from the outer liner to any underlay or flammable material.

Rips smaller than 75 mm on walls or roofs can be repaired by using a compatible flashing tape, but roof underlay damage greater than this requires a new piece of underlay captured by the cladding fastenings.

### 10.7.4.2 Underlay Support

Self- support underlay can be used unsupported on spans up to 1200 mm at pitches of 10° or more.  At roof pitches less than 10°, any underlay should be supported. Underlay support may be safety mesh, hexagonal galvanised wire netting, or alternative support such as builders strapping tape.

Safety mesh used as a fall arrest must be designed and installed to comply with Safety Mesh Standard AS/NZS 4389:2015.

Corroded galvanised safety mesh and wire netting can be damaging to any metal roofing and especially to pre-painted aluminium. Pre-painted aluminium cladding must be protected from contact with potentially corroding steel including netting, staples or fasteners.

## 10.7.5 Non-Residential Buildings

There is no requirement for underlay under the roof of an unlined building, underlay is normally used in internal situations.

The main reason why aluminium foil underlay is installed in commercial and industrial buildings under roof cladding is to maintain surface reflectance, limit heat emission, and enhance lighting conditions. These may be non-permeable, or permeable.

Permeable options normally use the same underlays as those for residential applications. Non-permeable is often reflective foil, either double-sided or white-faced.

Foil can be double-sided aluminium or one side may be white polythene faced.  Some types may have an anti-glare coating on one side. White polythene faced foils are often used in public buildings with an exposed roof structure to enhance the appearance from below.

They may also be lightweight, standard weight or heavyweight (light, medium or heavy duty under AS/NZS 4200.1) and may or may not be fire-retardant (having a Flammability Index of 5 or less when tested to AS/NZS 1530.2).

Although foil itself is not permeable, a foil underlay will not function as a vapour barrier unless all joints, penetrations, and intersections are fully sealed.
Non-permeable underlays should comply with AS/NZS 4200.1:2017.

### 10.7.5A Properties of foil (non-permeable) roof and wall underlays

| **Classification** | | **F1** | **F2** | **F3** | **F4** |
|---|---|---|---|---|---|
| **Grade/Duty - Industrial buildings** | | Extra light | Light | Medium heavy | Extra Heavy Self Support |
| **Type** | | Double Sided | Double Sided | Double Sided | Double Sided |
| **Application** | | Walls | Wall or roof | Roof | Roof |
| **Property** | **Unit** | | | | |
| Absorbency | g/m² | 0 | 0 | 0 | 0 |
| Water Vapour Resistance | MN s/g | > 450 | > 450 | > 450 | > 450 |
| Water resistance | mm head | ≥ 100 | ≥ 100 | ≥ 100 | ≥ 100 |
| Tensile Strength MD | KN/m | ≥ 6 | ≥ 7.5 | ≥ 9.5 | ≥ 12.5 |
| Tensile Strength CD | KN/m | ≥ 3.5 | ≥ 4.5 | ≥ 6 | ≥ 7.5 |
| Edge Tear Resistance MD | N | ≥ 30 | ≥ 35 | ≥ 65 | ≥ 80 |
| Edge Tear Resistance CD | N | ≥ 30 | ≥ 35 | ≥ 65 | ≥ 80 |

*Based on NZS/AS 4200.1:2017*

- An underlay is regarded as Fire Retardant if it has a FI (Flammability Index) of 5 or less when tested to AS/NZS

1530 Part 2.
- Self-supporting (S/S) is defined as strong enough to support its own weight up to a 1200mm span.
- pH between 5.5 and 8.0

## 10.7.6 Special Requirements

Buildings of the following types using metal cladding should have a sealed vapour barrier and are outside the scope of this Code of Practice. They are subject to specific design.

- Swimming pools.
- Buildings containing liquids stored in open containers.
- Buildings where water is used in manufacturing, cleaning or storage processes.
- Ice rinks, cold stores and freezers.
- Buildings where unvented gas heating is used .

A vapour barrier incorrectly located on the cold side of a structure or poorly installed can result in a rapid build-up of cavity or interstitial condensation and result in high costs for rectifying defects and damage.

Cold stores, freezers or buildings where the temperature is near or below 0° all require a fully sealed vapour barrier located on the warmer outer side of the insulation but are subject to specific design. See 15.5 Insulated Panels.

## 10.8 Wall Underlay

Permeable underlays are required under profiled metal wall cladding on residential buildings. Under direct-fixed metal cladding they should also be absorbent, but behind a drained cavity they may be either absorbent or non-absorbent

Under the NZBC wall cavities must be drained, not ventilated, i.e., they should be closed at the top to limit ingress of air in the cavity from entering the ceiling space.

Wall underlays must have a minimum side lap of 150 mm, and an end lap of 75 mm. Wall underlay on a drained cavity should be on the dry (inside) face of the cavity, and be rigid enough to restrain wall insulation from contacting the cladding, or have secondary strapping to achieve such

The COP does not require rigid air barriers to be used with profiled metal wall cladding in very high and extreme wind zones.

### 10.8A Properties of Permeable Wall Underlays

| **Classification** | | **W2** | **W4** | **W3** |
|---|---|---|---|---|
| **Grade** | | Heavy weight | Absorbent | Non-absorbent |
| **Type** | | Kraft | Synthetic | Synthetic |
| **Application** | | Any wall cladding | | **** See note** |
| **Property** | **Unit** | | | |
| Absorbency | g/m² | ≥ 100 | ≥ 100 | n/a |
| Water Vapour Resistance | MN s/g | ≤ 7 | ≤ 7 | ≤ 7 |
| Water resistance | mm head | ≥ 20 | ≥ 20 | ≥ 20 |
| Tensile Strength MD | KN/m | ≥ 9 | ≥ 2 | ≥ 2 |
| Tensile Strength CD | KN/m | ≥ 4.5 | ≥ 1 | ≥ 1 |
| Edge Tear Resistance MD | N | ≥ 40 | ≥ 100 | ≥ 100 |
| Edge Tear Resistance CD | N | ≥ 35 | ≥ 55 | ≥ 55 |

*Based on Table B1 of NZS 2295 Amendment 1:2017*

Run length:

- Kraft based underlays shall have shrinkage less than 0.5% and maximum run length of 10m.
- Synthetic underlays may have any length of run.

** Note - non absorbent underlays can only be used under an absorbent direct fixed cladding or non-absorbent cladding on a drained cavity.

Any underlay is regarded as Fire retardant if it has a FI (Flammability Index) of 5 or less when tested to AS/NZS 1530 Part 2.

pH between 5.5 and 8.0.

# 11 Natural Light

Clear Roof Sheeting explores the materials and installation methods available to provide natural lighting solutions for buildings in NZ. Other topics include:

- Types of roof light.
- Weathering and Durability.
- Loadings for roof lights.
- Thermal movement

## 11.1 Clause G7 NZBC

NZBC Clause G7 Natural Light requires habitable spaces to have enough natural light through windows and roof lights to safeguard against illness with enough visual awareness of the outside to prevent feelings of isolation.

**1. 'The workplace must have suitable and sufficient lighting'.**
**2. 'The lighting must, so far as reasonably practical, be by natural light.'**

All plastic sheets used with profiled metal cladding in New Zealand should comply with AS/NZS 4256.1 and should be tested in accordance with 18.3 Material Density, Melting Point, Expansion And Modulus.

*The most common form of roof lighting used in commercial and industrial buildings comprises of single skin matching profiled translucent sheets, running from ridge to eave. Alternatively, discontinuous profiled sheets placed in a chequerboard pattern, barrel-vaults or domes can be fitted on both sloping and flat roofs. All plastic roof lighting materials are supplied with films or surface coatings, stabilisers for durability, and long-term resistance to weathering and the discolouration termed 'yellowing'.*
*Roof lights are available to match metal profiles in a range of thicknesses and fire resistant grades. They are differentiated according to structural and safety requirements and imposed loadings.*
*Roof Lights should comply with the test provisions of AS/NZS 4257.*
**Only full-length roof lights running from ridge to eave must be used with unpainted galvanized roof cladding to avoid inert catchment corrosion.**

To maintain water-tightness and avoid thermal distortion, roof lights should be installed within the spanning capability of the profile, which depends on the profile shape and thickness. Additional support can be obtained from adjacent metal cladding by the use of mid-span supports (see 14.8.4 Midspan Supports)or alternately the thickness of the roof lights should be increased.

Safety mesh should be provided under all translucent sheeting which is accessible and more than 500 mm wide.

## 11.2 Materials

*In New Zealand, two groups of plastic roof lighting materials are commonly used with profiled metal cladding:*

- *Thermo-setting: GRP translucent glass-reinforced polyester.*
- *Thermo-plastic: acrylic, uPVC and polycarbonate.*

*Thermo-plastics softens and collapses under heat, and GRP can distort at 80º C but will yellow more rapidly above 60º C. Distortion temperatures varies between different materials and thicknesses.*
*As the performance of plastic sheeting is related to both the thickness and profile, designers should be aware that a nominal weight per square metre does not relate to different profiles.*
*The weight per square metre or mass per unit area has a tolerance of roughly 10%. However, it is a confusing measure because the test provisions of AS/NZS 4257 require the measure to be calculated from the area of the profile, including the overlap. Because the mass of plastic sheeting varies between profiles, the thickness will vary. This is the opposite measure to metal, where one thickness will have a varying mass per square metre for each profile.*
*When different profiles have the same mass per square metre, they have different thicknesses. It is not, therefore, possible to compare the performance of plastic sheeting by the weight, and it is recommended that all plastic roof lighting sheets be described by thickness.*

### 11.2.1 Glass Reinforced Plastic (GRP)

*Glass Reinforced Plastic ( GRP ) combines polyester resin and chopped glass fibre. AS/NZS 4256.3 requires sheets to contain a minimum of 22% glass fibre by mass and to be marked with their classification and weight.*
*GRP is suitable for in-service temperatures of -10° to 70°C and some GRP sheets are available in a fire resistant grade.*
*GRP should have a minimum thickness of 1.1 mm, but it is available up to 3 mm thick.*

#### 11.2.1A GRP Weight in g/m²

| *mm* | = | *g/m²* |
|---|---|---|
| *1.1* | | *1800* |
| *1.2* | | *2000* |
| *1.3* | | *2100* |
| *1.5* | | *2400* |
| *1.9* | | *3000* |
| *2.1* | | *3300* |
| *2.5* | | *4000* |
| *3.0* | | *4880* |

*The exterior surface of GRP is covered with either a polyester film or a layer of gel-coat cast as the sheet surface. Sheets can have a film or a coating on one or both sides or have a film on one side and a coating on the other. The performance of GRP is related to both light transmission and durability of the various films, and coatings can provide different performance for each category in different environments.*
*N.B. Performance in both of these areas is not necessarily directly related.*
The roofing contractor must ensure that the correct weathering surface of plastic sheeting is placed

**uppermost as the durability and warranty depend on placing the sheet the correct side up.**

## 11.2.2 Polycarbonate

*Polycarbonate is a tough, clear thermoplastic polymer with a higher deformation temperature than PVC.*
*Polycarbonate is manufactured with a co-extruded UV resistant top layer, which will resist weathering, but its durability depends on the thickness of the top layer.*
*Profiled polycarbonate sheeting has a limited spanning capacity and requires greater provision for expansion than GRP. It is available in thicknesses from 0.8 mm to 1.5 mm but is only available in a limited range of profiles.*
*Flat multi-wall extruded sheets with one or more air gaps have a thinner wall thickness but derive their rigidity from the shape of the profile. They are limited in spanning capability, but come in wide sheets, fixed into proprietary extrusions, and are suitable as continuous barrel vaults and as double skin roof lights.*
*Surface coatings provide different levels of durability, chemical resistance and weather resistance.*
**Polycarbonate sheets must not be fitted above sprinklers as they can drop out in a fire and interfere with the sprinkler's function.**

## 11.2.3 PVC

PVC is a compound of polyvinyl chloride manufactured with stabilisers but without plasticisers that complies with AS/NZS 4256.2. Profiled PVC roof lights have a limited spanning capacity and need greater provision for expansion than other plastics or metals.

Profiled PVC sheeting ranges from 0.8 mm to 1.5 mm in thickness but is only available in a limited range of profiles. PVC softens at 80°C and will act as a smoke vent when heated during a fire. It has a service temperature of 60°C and a tensile strength of 52 MPa at 20°C.

*PVC may not satisfy the 15-year durability requirements of the NZBC; it is not regarded as suitable for commercial or industrial use and should not be used in habitable buildings.*
**PVC sheets must not be fitted above sprinklers, as they can drop out during a fire and interfere with the sprinkler's function.**

# 11.3 Types Of Roof Lights

*Roof light installations can be grouped into one of the following types:*

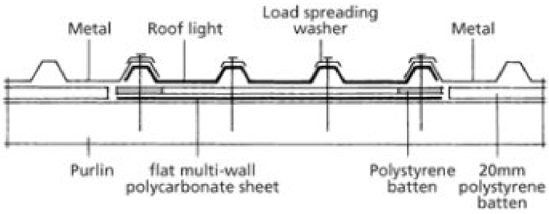
1. *Single skin.*
2. *11.3A Double Skin Rooflight*
   a. *Where the roof cladding is fixed to battens and uses a flat multi-wall polycarbonate sheet.*
   b. *Where an additional sheet is fixed above, as shown in 11.3B Double Skin Rooflight (No Spacers) and 11.3C Rooflight with Spacers*
3. *11.3D Continuous Vaults.*
4. *11.3E Individual Domes–Light tubes made from acrylic or polycarbonate are usually manufactured with a flashing suitable to weather most roof cladding profiles.*

Proprietary opening window units or skylights made from acrylic also have powder coated frames and are provided with weathering curb flashings, but they should be compatible with the roof cladding and should be installed as required in 9 External Moisture Penetrations.

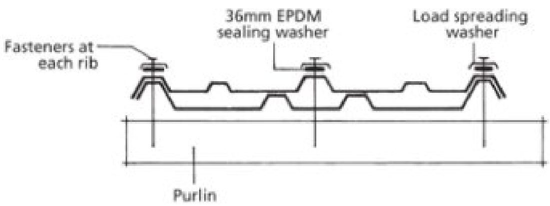
Acrylic or polycarbonate tubes, skylights or domed roof lights should not drain onto unpainted galvanised roof cladding or onto galvanised fasteners. See 4.12 Inert Catchment.

Proprietary GRP sheets are available that can be used as double skin roof lights. A liner panel GRP or PVC sheet can be used to minimise condensation, but the air gap should be sealed.

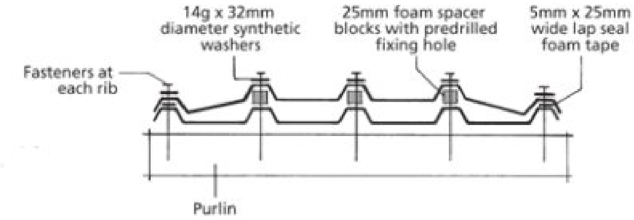
## 11.3A Double Skin Rooflight



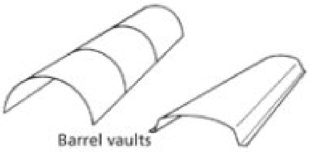

## 11.3B Double Skin Rooflight (No Spacers)



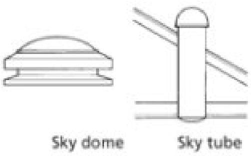
## 11.3C Rooflight with Spacers




## 11.3D Continuous Vaults




## 11.3E Individual Domes



# 11.4
# Light Transmission

*Daylight glare levels, diffusion, and location are more important than light intensity, and these conditions should be determined to ensure the plastic sheeting is suitable for the intended use or purpose of the building.*

*Normal roof light areas range from 5% of floor area for warehouses to 10 – 15% for industrial buildings, and 20% for sports halls and for factories where intricate work is done.*

*For urban areas where air pollution reduces the level of natural light, or where roof lights are double skin or are specified tinted, the proportion of roof lights should be increased.*

*Typical light transmission for new double-skin roof lights is around 70%, and diffusing agents can be added during manufacture to minimise glare and solar gain. Roof lights will perform better, maintain maximum light transmission, and last longer if they are kept clean by washing down with water and mild detergent, at 1 – 2-year intervals. Although films and gel-coats will vary in their resistance to surface deterioration, any dirt or lichen build-up will shorten the life of roof lights.*

*The light and heat transmission of plastic roof lights can be reduced by adding tints to polycarbonate sheeting or pigments to GRP sheeting. Such tints can lower the light transmission to as low as 25% compared to 90% for clear sheets, and heat transmission can be reduced by over 50%.*

## 11.5 Weathering And Durability

*Plastic roof lights are resistant to normal weather conditions because they are protected from ultraviolet radiation (UV), temperature changes, and ingress of moisture by surface coatings or laminated films.*
*Surface protection includes PVF or polyester films, liquid gel-coats on GRP sheets or co-extruded layers on thermoplastic sheets. Their resistance to yellowing, surface crazing and erosion, fibre prominence in GRP and embrittlement all depend on this protective treatment.*
*The surface protection provided may also determine their resistance to aggressive chemical environments. PVF films give a very good chemical resistance, provided that the film is undamaged during the life of the product. Gel-coats can also be used in chemically aggressive environments that would be unsuitable for metallic coated steel cladding.*
*Surface protection films and coatings are very weather-resistant but should be kept clean and well maintained, but the translucence of all plastic sheeting will reduce over time, even if the sheets are cleaned regularly.*
*UV degradation depends on location, orientation to the sun, and on the UV intensity. Some inferior films on GRP sheets can discolour and craze in as little as three years. Higher grade films, however, proved to provide useful light transmission for 15 years.*
*Certain types of gel-coat and polycarbonate sheet with good protection can provide useful light transmission for up to 20 years. PVC has a useful light transmission life of only 2 – 5 years and it can become brittle due to UV exposure. Fire-retardant additives may cause fire-resistant sheeting exposed to UV light to discolour more quickly.*

All plastic sheeting is subject to mould growth, particularly in areas of high humidity. Take care not to damage the film surface when removing mould growth. See 16.7.1 Lichen And Mould.

*Where the roof is constructed using composite panels, factory assembled rooflights are the most appropriate rooflight solution. See 15.5 Insulated Panels.*
*The use of double skin sealed rooflight panels will also reduce the risk of condensation.*

# 11.6 Loadings

## 11.6.1 Point Load. Walking Traffic

All plastic roof lights are classified as brittle roofing and is not suitable for roof traffic, unless specifically tested under the point load test provisions of AS 4040.1, As/NZS 4040.4, and AS/NZS 1562.3: 2006.

AS/NZS 1562.3 :2006 requires the provision of safety mesh under all plastic sheeting subject to local statutory or national building code regulations. The HSE Act 1992 classifies accessible roof lighting as hazardous and requires the use of safety mesh under or above translucent sheets over 500 mm in width.

*Although normal chopped strand GRP of sheet thickness greater than 1.7 mm can resist the impact load to demonstrate resistance to accidental fall, this strength is not expected to be retained for more than 5 –10 years, and the sheeting is therefore classified as brittle. GRP sheet that is reinforced with a woven glass mat, may remain trafficable for 20 years, but this should be proven by testing.*

Safety mesh can damage plastic sheeting by expansion movement and walking traffic, and should be isolated at the purlin. See 14.8.6 Purlin Protection.

The mechanical properties of plastic roof lights differ from those of profiled metal cladding in that they are more flexible which allows them to deflect to a greater extent without damage. Foot-traffic and or access for maintenance should be considered at the design stage, so one sheet or a reduced width is provided so a workman may step over and not on, the roof light.

**Safety mesh must be provided under all translucent sheeting which is accessible and wider than 500 mm.**

**A temporary walkway must be provided for installation where the plastic sheeting is more than one sheet width, and if access for maintenance is required the walkway must be permanent. See** 13.6 Walking On Roofs.

## 11.6.2 U.D.L. Wind And Snow Loads

*The maximum performance of plastic roof sheeting for spanning capability and deflection under a uniformly distributed load depends on the section properties and type of material of the profile. The section properties depend on the number and depth of corrugations and the thickness of the profile.* 3.5.6 Section Properties

*The uplift pull-through load performance depends on the number of fasteners per square metre and the type and size of the washer.*

*Profiles which have deeper ribs are more rigid and will deflect less, but will not provide any greater resistance to pull-over at the fixings, unless the sheet thickness is increased. Greater spans also require a thicker sheet. Additional fixings will increase resistance to pull-over failure at fixings, but will limit deflection.*

Roof lights located in the peripheral zones of high wind design load should have provision for the higher load in this area by the use of additional fixings, reduced purlin spacings or by increasing the roof light thickness.
Deflection of plastic roof lighting due to UDL wind or snow loading should be limited to less than 1/30th of the span or 50 mm.

All plastic roof lighting should be tested to withstand wind loads and extrapolation is not acceptable as a statement of performance.

On buildings higher than 10 m or areas located in the peripheral zones of high wind design loads, near verges, eaves or ridges it is better practice for roof lights to be omitted.

**Plastic roof sheeting must match the design load of the adjacent metal roof cladding. This can be achieved by using a mid-span support or by increasing the weight of the plastic sheet.**

Excessive deflection due to long spans can open up side laps or cause failure in compression at the fixing points.

# 11.7 Thermal Expansion

*Although the figures quoted below are the theoretical expansion rates of different plastic roof lighting materials, the actual expansion rate will differ. See 7.3.2 Roof Cladding Expansion Provisions.*
*As PVC and polycarbonate expand almost six times more than steel, they should only be used in lengths not exceeding 3 m. Translucent plastic sheets, however, do not normally reach the same temperatures as adjoining metal sheets.*

## 11.7A Material Expansion Rates

| | mm per 50° C per 1 m length |
|---|---|
| Steel | 0.6 |
| GRP | 1.1 |
| PVC | 7.0 |
| Polycarbonate | 3.2 |

PVC and polycarbonate sheet in lengths up to 3 m require 6 mm oversize holes to all fixings. The fixings should always be fitted in the centre of the holes, which can be achieved by pilot drilling. It is recommended that a stepped drill bit be used to ensure the correct size hole.

*GRP roof lights also require provision for thermal movement, but to a lesser degree. See 7.3.2A Favourable Circumstances for Controlling Expansion.*
*Special screws which drill their own clearance hole are suitable for polycarbonate and GRP sheeting.*

# 12 Fitness For Purpose

In addtion to Corrosion (NZBC: B2 – Durability), other issues which may affect the lifespan or perceived quality of metal roof and wall cladding, include:

- Oil Canning.
- Purlin Creasing.
- Colour Differential.

# 12.1 Roof Noise

It is impossible to prevent expansion, but it can be controlled by reducing the surface heat of the roof cladding by using lighter colours and ventilating the roof space.

*Transverse expansion is accommodated by the concertina action of corrugation or rib of metal cladding and does not usually give rise to any noise. However, because flashings are stiffened at 90° to the cladding, there is differential movement between them, which requires expansion provisions for fastening, and to minimise noise associated with this movement.*

*All materials expand or contract with changes in temperature, but those with a greater mass usually move less or more slowly than thin sheet materials. Metals expand more than other building materials, except plastics which can expand more than steel. Green or wet timber contracts on drying, producing shrinkage but it also expands or contracts with temperature fluctuations.*

## 12.1A Poor Purlin to Rafter Connection

*Poor purlin to rafter connection-tightness often causes noisy roofs.*

*Roof expansion noise can be caused by the energy released when the roof expands relative to its support and sliding occurs at the purlins, clips, or fasteners. Friction between the roof cladding and its support controls the sliding; surfaces with a lower coefficient of friction, e.g., metal to metal, would slide more easily than metal to timber.*

*When the friction is exceeded, and the metal roof cladding moves, it creates noise. Further temperature increase will cause a stress build-up, until the limiting static friction point is reached again, and the cycle repeats. During each cycle the thermal energy is released impulsively, and the higher the friction the louder the noise.*

The noise can be reduced if expansion can take place uniformly by using sliding fixings, or interposing low friction material (e.g., PVC noise tape) between the roof and its support.

Where the roof is rigidly fixed, the purlins will likely tend to rotate, and this can also produce noise.

When using long length roof cladding, oversize holes or other suitable expansion fixings are essential to avoid noise.

The many other factors that determine if a roof will produce undue noise, include:

## 12.1B Roof Noise — Fixing Issues

- Secret-fixed roofs, where the clip fits too tightly over the rib or is misaligned.
- Over-nailed roof cladding, i.e., too many fasteners.
- Over-tightened roof cladding, i.e., nailed or screwed too tightly. The 'ticking' or creaking noise heard when the sun goes behind a cloud is usually caused by metal against metal, or at the fastener hole.
- Crest fixing produces more noise than pan fixing, because of the movement of the fastener at the shank hole.
- Noise can be caused by inadequate timber nailing, causing differential movement at timber joints.

## 12.1C Roof Noise — Structural Issues

- Gutters and valleys should be free to expand and move independently of the cladding and not have "wings", which preclude any movement.
- Rigid framing and closely spaced purlins cause more noise than a flexible structure, e.g., steel portal frame construction is more flexible than laminated timber.
- Roofs which are free to expand should be kept clear of concrete walls and other structures.
- Specific problems are often due to structural detailing which requires special provision, e.g., where solid timber construction and a dark coloured cladding are combined.
- Flashings should be limited to 12 m in length. Otherwise, noise is likely as transverse flashings expand to a greater extent than the roof cladding that they are attached to. Slip joints should be used in sheets longer than 12 m.
- The edges of all flashings should be formed as shown in 8.3.2 Flashing Edges to avoid 'whistling', or a wind created noise known as "motor-boating"—a fast vibrating sound like the noise of an engine.
- Flashings should be 0.55 mm steel or 0.9 mm aluminium and no wider than 300 mm.
- Flashings should not touch the pan of roof cladding.
- Insufficient clearance between a penetration and the cladding may cause noise.

## 12.1D Roof Noise — Material Issues

- Using metals with a high rate of expansion, e.g., aluminium.
- Dark coloured and unpainted, weathered metallic coated roof cladding absorbs more heat than light coloured claddings.
- Impulsive energy release can give rise to 'pistol shot' noises that are very disconcerting to live with, but a dark coloured roof may only be a contributing factor, and often the cause may be a strong and rigid timber frame. Solid timber framing is well known for such noise.
- Shrinkage associated with drying timber with a high moisture content.
- Underlay that overlaps too far into a spouting or gutter can give rise to a noise known as 'flutter'.

## 12.1E Roof Noise — Ventilation Issues

- When insulation is placed hard up to metal cladding, more heat is retained, and the metal surface temperature becomes higher than an uninsulated roof.
- An attic space with insufficient ventilation increases the temperature within the roof cavity.
- Roof cladding in an exposed position loses its absorbed heat more quickly than one that is in a sheltered valley.
- Skillion roofs and curved roofs without provision for ventilation are subject to greater fluctuations of temperature than roof attic construction.

## 12.2 Purlin Creasing

Due to improvements in colour coating technology, the level of reflection of new pre-painted roof sheeting is now considered to be higher. Overdriven nails or screws can produce visible distortion on the purlin line in the pan of trapezoidal profiles that cannot be easily remedied.

*Trapezoidal profiles with a wide pan manufactured from 0.4 mm steel and 0.7 mm aluminium are particularly susceptible to purlin creasing, and although it does not affect performance, their appearance can be aesthetically unacceptable*

It is the responsibility of the roofing contractor to ensure that nails are not overdriven. A nail or screw should only be driven into the purlin to produce a 50% compression of the sealing washer or until the roof is firm. Using too many fasteners should also be avoided, and nails should always be fixed at right angles to the roof.

Before fixing the roof cladding, the contractor should check the alignment of the purlins or girts. Purlins should be aligned within 5 mm tolerance of each other to avoid purlin creasing.

Purlins should be accurately positioned with their top face parallel to the rafter and should be fixed to a straight line.

When appearance is important or where wide pan trapezoidal cladding is close to eye level, heavier gauge cladding should be specified because light gauges such as 0.4 mm steel and 0.7 mm aluminium are likely to show distortion. Purlin creasing will happen on both concave and convex curved roofs if the recommended purlin spacings are exceeded, and great care should be taken to align purlins on such roofs.

Purlin creasing can be exacerbated by roof traffic. 13.6 *Walking On Roofs*

## 12.3 Oil Canning

Distortion of flat metal areas is an aesthetic problem associated with the manufacture of metal roof and wall cladding and flashings. Flat pan architectural metal panels, wide flashings, and profiled metal cladding with wide pan configurations without stiffening ribs are all liable to show distortion in flat metal areas. It is known as oil-canning or panning.

Oil canning can be defined as visible waviness in the flat areas of metal roofing and wall cladding. It can also be referred to as panning, canning, stress wrinkling or elastic buckling, and is caused by differential stresses in the metal. As the metal tries to relieve these stresses in panels with high width to thickness ratios, material buckles out of plane producing the characteristic waviness of oil canning

It has an aesthetic effect and is not a structural or durability issue. Some highly reflective paint finishes and metals or different light conditions can exacerbate the visual effect of oil canning. Some distortion is inevitable in light gauges. It can become an issue of customer acceptance because customer expectations are often unrealistically high.

The degree of waviness can be hard to measure and is highly dependent on viewing angles, the position of the sun, and the reflectivity of the surface. Cladding installations with a high degree of visibility should be designed to minimise oil canning.

Oil canning is more common where the width of unformed sections is large. It can usually be avoided or minimised in normal rib and trough section profiles with a maximum pan width of 300 mm, and flashings that have a maximum unformed width of 300 mm. See 8.1 Flashing Materials

In standing seam roofs with pan widths of more than 300 mm, some oil canning is normally evident. Many designers regard oil canning in such profiles as inherent to the material and treat it as a desired effect accentuating the material's natural characteristics.

Manufacturers and installers should minimise unintentional non-flat conditions, and any visual waviness should be relatively even and regular.

There are various causes for oil canning:

- material;
- roll tool design and setting;
- installation; and
- expansion allowance.

### 12.3.1 Material

All profiled metal roof and wall products begin in a coil form. Stresses induced during coil production can contribute to oil canning. Examples of these stresses are:

- Full Centre: The coil is longer in the centre of the strip than near the edges. This creates buckles and ripples in the mid-coil area.
- Wavy Edge: The coil is longer on one edge of the strip. That causes waviness on the long edge.
- Camber: The side edge of the coil deviates from a straight line. The normal tolerance for a 1200 mm wide coil is a 2 mm deviation in a 2 m length, but some forming processes and end uses cannot tolerate that variation.
- Uneven Material Strength: During the forming process material may tend to draw unevenly from the softer areas rather than evenly as designed; it leaves excessive material in the "harder" areas.
- Slitting: Generally, coil for flashings and narrower products are cut by slitting from a single, wider master coil. Slitting of a master coil can release and redistribute residual forces. It can also mean that different qualities of the master coil are modified or changed in the slit coil, i.e., a full centre in a master coil can become a wavy edge in a slit coil and the slit coil may not retain all the attributes of the master coil or sister coils.

## 12.3.2 Tool Design

By the nature of the process, many stresses are created during roll forming. These must be minimised and equalised as much as possible during manufacturing. Forming tools must be designed to form the material progressively.

Corrugated and ribbed profiles are most often formed from the centre and moved outward thereby "pushing" the differential stresses to the edges of the sheet. Generally, profiled metal rib and corrugated profiles, flashings, and most trough sections can be expected to provide finishes free of avoidable distortion.

Standing seam profiles typically need more forming on the edges of the feed material and little or none in the centre of the sheet, which tends to trap uneven stresses in the centre of the profile. Often one edge requires more forming than the other, meaning the stresses developed are not even in the sheet.

Some evenly distributed oil canning can normally be expected in standing seam products with a width of more than 300 mm, and it is considered acceptable.

## 12.3.3 Installation

*Oil canning can occur in fixed cladding, even though it does not fit accurately, when fixings are too far apart or when fixings are overdriven. It can also result from an uneven substrate, irregular bearing on the purlins or by the structural framing being out of line.*

Thermal expansion can also increase oil canning. Longitudinal expansion should be accommodated by using sliding clips allowing movement. See 15.4.4.3E Expansion Clips. Transverse expansion is usually accommodated in the upstand of the profile, but this can only happen if adjacent pans are not in contact at the base. Wide perimeter flashings must be designed to allow for independent movement of the flashing and the cladding.

A convex curve in the roof structure can cause canning as it puts the pan of the profile under compression. Sometimes this curve is inadvertent. Concave roof cladding and flashings give rise to oil-canning because the pans are in compression. There are limitations on curved radii to avoid oil canning. See 15.1 Curved Roofs.

Commercially designed truss sections and rafters may have camber induced in their manufacture, anticipating deflection under load. The degree of curve that may be accommodated by any profile is largely determined by the width of the pan and is, also, affected by the material thickness and grade.

## 12.3.4 Minimising Oil Canning

Good design and installation can minimise oil canning.

Materials:

- Use thicker material.
- Use low gloss paints or embossed surfaces.
- Use natural weathering materials that dull over time.

Flashings:

- Limit flashing width to 300 mm.
- Limit the joined length of fixed flashings to 12 m.
- Attach wide flashings with brackets that allow independent thermal expansion.
- Manufacture a stiffening swage into flashings that have a face width greater than 200 mm.
- Do not fix flashings to timber with a moisture content greater than 18%.

Cladding:

- Limit cladding length.
- Ensure the purlin alignment avoids convex curving.
- Inspect for flatness before installation.
- Avoid thin materials.

## 12.4 Colour Differential

*It is both the cladding manufacturer and the roof cladding contractor's responsibility to ensure that the same brands of pre-painted material are used on the same building.*
*Failure to do so could result in differences in colour, gloss and weathering, which quickly becomes obvious.*
*The differences come from different paint formulations and do not necessarily indicate that the materials will perform differently in service. All New Zealand manufacturers provide information about the manufacturer, the type of coating and the manufacturing date in the branding on the reverse side of uncoated and colour coated steel. Double-sided coatings are not branded.*

### 12.4.1 Touch Up

*Air-drying touch-up paints have different weathering characteristics to the baked-on finish of pre-painted coating systems and variations in natural light conditions will emphasise these differences, producing an unacceptable aesthetic appearance.*

Spray cans should not be used for repairing scratches on pre-painted sheeting.

If the scratch is obvious from 3 m, the sheeting should be replaced, if not then it should be left alone. Minor surface scratches become less noticeable as the coating weathers and are best left as they do not appreciably affect the corrosion inhibiting properties of the material.

Widespread damage caused by rough handling or an accident, however, should not be corrected by repainting, but the affected material should be replaced.

## 12.5 Transport, Handling And Storage of rooflights

*All roof lights should be handled and stacked with care as film surfaces are easily scratched, and heavy stacks can damage lower sheets.*

*All roof lights should be stored flat, the right way up, on 75 mm battens not more than 1.2 m apart. Stacks should not be higher than 1 m and should be covered and protected from rain and sun. Thermoplastic sheets can overheat and deform in a stack, and exposed stacks can permanently discolour due to the effect of sun and water.*

### 12.5.1 Maintenance

*First maintenance after 12 months requires cleaning any grime or debris using warm water and a stiff bristled brush. Every 2 - 3 years rooflights should be inspected for damage, the condition of the flashings, and sealants and the fixings should be checked for tightness.*

**Roof lights must not be painted over as this renders them hazardous to maintenance workers.**

Because painted roof lights appear no different in place than metal sheets, this practice can be dangerous for any workers carrying out maintenance work on the roof. Painting can also cause heat distortion which can lead to premature failure.

As a warning, primary and secondary fasteners can be brightly coloured, providing a contrast with the remainder of the roof cladding surrounding the roof light areas. The area can also be marked around with a distinctly painted stripe.

Lichen will accumulate on plastic roof lighting wherever there is a source of nutrients, but it should be removed with care. See 16.7.1 Lichen And Mould.

# 13 Site Practice

Guidelines for site practice, including:

- Safety.
- Transportation and Handling of Material.
- Walking on Roofs.
- Tools of the Trade.

## 13.1 Safety

The NZBC requires that people are safeguarded from injury during construction but this relates to injury as a result of structural failure rather than due to a mishap.

Health and Safety at Work Act 2015 covers safety in workplaces generally.

**Object of Act**

The object of this Act is to promote the prevention of harm to all persons at work, and other persons in or in the vicinity of a place of work.

### 13.1.1 Responsibilities

**Compliance with the legal requirements of the HSE Act is not the only responsibility of anyone associated with working at height.**

**Employers have a duty of care to take all practicable steps to ensure the safety of employees, to provide and maintain a safe working environment, and to provide and maintain facilities for the safety and health of employees.**

**They must also ensure that equipment is safe, that working arrangements are not hazardous, and that procedures are in place to deal with any emergencies that may arise.**

Taking all practicable steps means doing what is reasonable and possible to be done in the circumstances, taking into account:

- the severity of any injury or harm to health that may occur;
- the degree of risk or probability of that injury or harm occurring; and
- the availability, effectiveness and cost of the possible safeguards.

Employers are also responsible for the health and safety of people who are not employees and must take all practical steps to ensure that employees do not harm any other person, including members of the public or visitors to the site.

The HSE Act requires employers to keep a register of work-related accidents including every accident that harmed or might have harmed someone. Employers are required to notify serious harm that occurs to employees to the nearest Worksafe office within seven days.

Employers are also required to investigate all these accidents to determine whether they were caused by a significant hazard.

If a person suffers serious harm, the scene of the accident must not be disturbed, unless it is to:

- save a life or prevent suffering,
- maintain access for essential services, e.g., electricity or gas; or
- prevent serious damage or loss of property.

Worksafe will advise if the accident is to be investigated.

Supervisory persons who control places of work must take all practical steps to ensure the safety of persons in the place of work. They are responsible for the safe use, handling, transport and storage of all materials and substances used on the work site or in any other place of work.

## 13.1.2 Training

Employers must ensure employees are either sufficiently experienced to do their work safely or are supervised by an experienced person. Employees must be adequately trained in the safe use of the equipment work-place, including protective clothing and equipment.

Employees and self-employed persons have a responsibility for their safety and health, and they must also ensure that their actions do not harm anyone else.

Self-employed persons have equal responsibilities as the employer to ensure that they are adequately trained and informed in all legal and practical matters regarding safety.

## 13.1.3 Working At Height

Where a person may be at risk of an injury from a fall, suitable and safe means to prevent such a fall must be provided.
Safety fall protection systems include:

a. The installation of an approved safety mesh over the total area to be clad (barrier).
b. Edge protection for the total periphery of the area to be clad; including a scaffold or a guardrail fixed 1 m high to standards which includes a bottom and middle rail (barrier).
c. Travel restriction consisting of an anchorage line and a safety belt.
d. Fall arrest devices such as an individual safety harness.

Options (a) and (b) are the preferred methods of working safely at height.

Surfaces with fall-protection barriers (a) and (b) are regarded as an enclosed working environment and the roofer is free to work within this area.

A minimum safety standard for all workers on roof areas over 3 m high requires that:

- A safety harness (fall-arrest system, option d) must be used for all areas that do not have a fall-protection barrier (a) and (b).
- Travel restriction equipment (c) is required for all roof areas that do not have a fall-protection barrier or secure footing .

A fall protection barrier includes any barrier that will prevent a person from falling. It can be tile battens or roof framing at less than 500 mm centre to centre, a roof safety mesh or a work platform.

Edge protection can include scaffolding, scissor hoists or a guardrail system.

**Permanent anchor points for a static line or other fall arrest device, must be installed in all buildings, exceeding 100 m², where the roof pitch exceeds 20°, or where maintenance is required for the servicing of air conditioning units and other roof mounted equipment.**

## 13.1.3.1 Roof Edge Protection

**Where a person may fall more than 3 m, and there is no other means to prevent a fall, edge protection must be provided.**

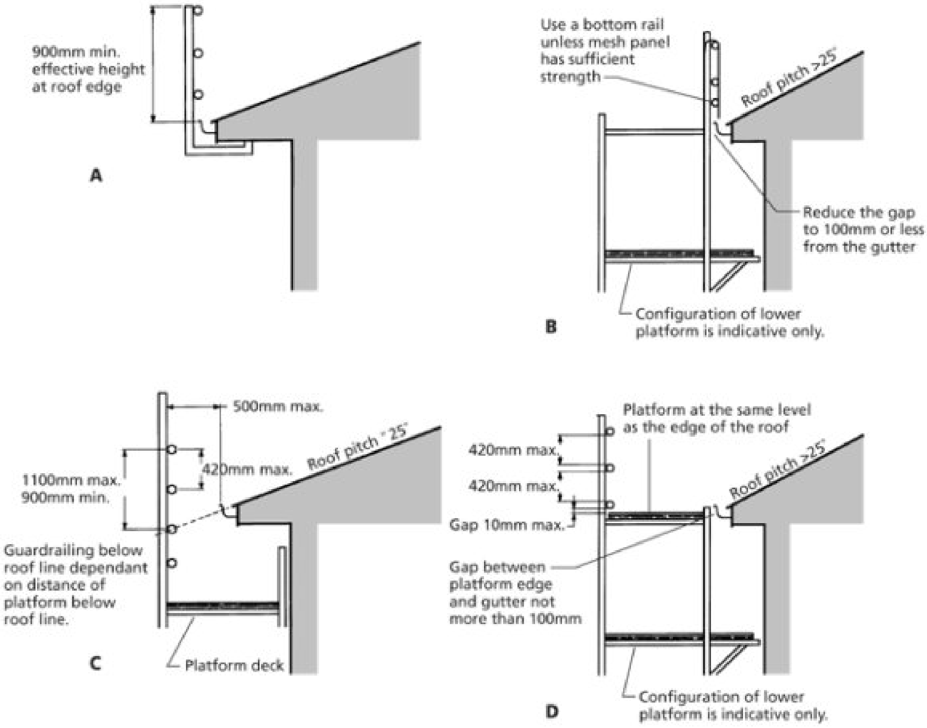
**Edge protection is required to comply with AS-NZS 4994.1 general requirements and 4994.2 installation and dismantling.**

**People must be able to gain roof access without climbing over guardrails.**

**Access points must not undermine the integrity of the edge protection. Gates or other devices that guard openings must be self-closing and ladders must be placed as close as practicable to the entry and fully secured.**

Main contractors and sub-contractors should liaise to provide an integrated fall protection method for all people working on a roof as a common safety system is more efficient than every subcontractor installing their own. There are many options for acceptable scaffolding and guardrail edge protection, some of which are shown in 13.1.3.1A Scaffolding and Guardrail Edge Protection.

## 13.1.3.1A Scaffolding and Guardrail Edge Protection




This Code of Practice states ways of managing exposure to the risk of falling and encourages the use of an enclosed environment, so it is not possible to fall from or through the structure.

Personal fall protection systems are only useful in a limited range of applications on a roof and may add unnecessary risk to people working on a roof.

## 13.1.4 Residential And Light Commercial Roofing

Worksafe is unable to give any dispensation to the Roofing Industry from the requirements of the Health and Safety in Employment Act 2015 and the Regulations of 1995.

Most residential buildings fall within a 3 m to 4 m height category and this height is measured from the edge of the soffit. Worksafe recognizes that experienced workers may work within these heights without the necessity of edge protection or harness surface, but certain conditions apply.

- Workers should have undergone safety training.
- Pitched roofs with a smooth surface less than or equal to 30°.
- Pitched roofs with a textured surface less than or equal to 35°.

The intention of these conditions is to make the act of cladding the roof by skilled and trained workers, a separate act to that of working on a roof by other trades.

Textured surface roofs such as textured metal tiles, unglazed clay tiles, and asphalt shingles are regarded as providing an extra 5% secure footing, as opposed to a smooth surface. Smooth surface roofs include painted metal tiles, unpainted, and pre-painted profiled metal cladding.

Before any work is commenced, in all cases there is a requirement that the roofing contractor will have had sufficient safety training and education, that site hazard identification has been undertaken, and that a contractors safety policy is in place.

If there are individual site hazards, precautions need to be implemented at all heights. Hazards should be eliminated, isolated or minimised by the use of fall protection equipment.

*Site hazards include:*

- *Brittle roofing such as skylights, translucent, fibre cement or corroded sheets.*
- *Slippery roof surfaces resulting from paint finishes, moss and lichen or dew and rain.*
- *Roof pitches above 35°.*
- *Roof projections such as pipework and flashings.*
- *Any roof penetration larger than 600 mm by 600 mm.*
- *Steeply sloping building sites.*
- *Open foundations or drains.*
- *Working within 2 m of any roof edge.*
- *Wet or muddy ground conditions.*
- *Rotten timber framing.*
- *Fire damaged elements.*
- *Plant and equipment.*
- *Reinforcing starter bars.*

*A guideline for the prevention of falls is available from Worksafe.*

## 13.1.5 Limitations Of Fall Arrest And Travel Restraint

Whenever possible, an enclosed environment should be provided for roof installation and repair work so it is not possible to fall through or off the roof.

*Harnesses are only appropriate for certain conditions, such as maintenance after the roof is completed or re-roofing work, and they are not satisfactory when snagging hazards are present.*
*The use of fall arrest harnesses or travel restraint systems is not the preferred alternative for people working on roofs, as these methods have limitations including the following:*

- *Individual fall arrest anchors should have a capacity of at least 15 kN and roofs are generally not designed for such loadings; other anchorage points should withstand a load of 6 kN without failure.*
- *The location of fall arrest anchorage points on roofs cannot be located directly above head height.*
- *Fall arrest systems require a minimum of 5.5 m vertical clearance below the working surface to ensure the user does not hit the ground or another obstruction before the fall being arrested. This distance is required to be greater if static lines are used or ropes are slack.*
- *In contrast to guardrail or scaffolding, fall arrest and travel restraint systems require a high level of training and supervision to ensure their safe use.*

- *Ropes and lanyards can become tangled and snag on obstructions on the roof, particularly when a number of workers are located on the roof.*
- *It can be difficult to have an effective rescue procedure, to ensure users are rescued before injury occurs, without putting other people at risk.*
- *Persons suspended in harnesses after falling can lose consciousness or suffer modified cardiac rhythm if not rescued promptly and the rescue procedure should ensure persons can be rescued in less than 5 minutes.*

*Fall arrest systems must not be used unless specific training has been completed, that more than two people are located on site and any rescue procedure must not put other persons at risk.*
*The solo operation using fall arrest equipment is hazardous because there will be nobody to rescue a worker who could be unconscious and heavy. In some situations, at least two people may be required to safely rescue a person who has had a fall in a harness.*
*Systems that prevent a fall from occurring should be used in preference to fall arrest systems. Travel restraint systems are a higher order control in comparison to fall arrest systems because they prevent a fall actually occurring. However, travel restraint systems can be very difficult to set up and often impractical to use, particularly where corners of a roof require accessing or the roof has a number of penetrations.*

**Where access to the corner of a roof is required, workers must be attached to two or more sets of ropes and anchorages to prevent a fall from either edge of the roof. While accessing the anchorage points, the user must be restrained so that a fall cannot occur.**

*Persons using travel restraint systems require a high degree of training, as do persons using fall arrest systems, but the training for these systems differs.*
*When used in isolation, fall arrest and travel restraint systems are nearly always unsuitable control measures for a complete roof installation, and it is extremely difficult to set up a fall arrest system so that the user will not hit an obstruction before the fall being arrested.*

**The travel restraint system must prevent a person falling from the edge or through the roof. The use of travel restraint systems is not acceptable on fragile roofs such as plastic or asbestos cement roof cladding.**

*Fall arrest and travel restraint systems are generally only suitable for minor work such as:*
- *roof inspection (not on fragile roofs);*
- *installation of skylights and ventilation fixtures;*
- *installation and removal of perimeter guardrail systems;*
- *fitting ridge capping on metal roofs;*
- *replacement of some isolated parts of the roof;*
- *installations and removal of television aerials and other similar communication equipment; and*
- *painting and cleaning;*

## 13.1.6 Access

*Safe access should be provided to the working area at height by the provision of one of the following:*

- *a permanent access platform or tower if the height is over 9 m;*
- *a power-operated work platform, e.g., a cherry picker, scissor hoist or approved forklift truck; or*
- *a ladder.*

*A ladder can only be used by one person at a time and must be:*

- *a step ladder of maximum length 6 m;*
- *a single ladder of maximum length 9 m; or*
- *an extension ladder of maximum length 15 m.*

*To use a ladder safely, it must be:*

- *set at an angle of 76° (4 up - 1 out);*
- *secured against sliding top and bottom;*
- *set on firm level ground; and*
- *protruding by one metre higher than the roof;*
- *used by no more than one person at a time.*

## 13.1.7 Scaffoldings

Scaffolding must comply with AS-NZS 1576 Scaffolding Standard.
Any person can erect scaffolding providing that it:

- is less than 5 m high to the top of the working platform;
- is erected in a tradesman like manner;
- uses sound materials;
- is properly braced and tied;
- conforms with the scaffolding regulations;
- conforms with AS/NZS 4576; and
- conforms to the SARNZ guidelines.

Scaffolding greater than 5 m in height must be erected by a certified scaffolder and must be reported to the construction safety inspector at the nearest district office of Worksafe.

Working platforms more than 3 m high must be protected with guardrails, mid-rails and/or toeboards; however, it is recommended that all working platforms be so protected.

These requirements also apply to the erection, alteration or dismantling of all suspended scaffolds.

To prevent any inward or outward movement ties must be fixed to standards and be uniformly spaced vertically and horizontally over the face of the scaffolding.

Transverse diagonal bracing is required to stiffen the scaffold. It must be fixed to each end pair of standards and at not more than every tenth pair of standards. To resist movement due to wind, longitudinal diagonal bracing must be fixed to the face of the scaffold and at regular intervals along its length.

Ladders, steps or stairs must be securely fixed to the scaffolding, either internally or externally, to provide safe access.

## 13.1.8 Mobile Scaffolds

Mobile scaffolds are freestanding scaffolds supported on wheels or castors and must only be used safely on firm level surfaces with the wheels effectively locked, braced, and stable against overturning.
Working platforms must be fully decked and provided with guardrails and toeboards as per fixed scaffolds .

## 13.1.9 Personal Safety

Workers installing roof and wall cladding should take personal precautions to avoid damage to skin and eyes due to ultraviolet radiation.

Sunscreen or sunglasses should be used, particularly during the time of highest exposure (11 am to 2 pm ).

Ultraviolet radiation burning can be mistaken for windburn on windy days, and cloudy days can also produce severe burning. Some workers with a fair or sensitive skin., should always wear sunscreen protection when laying roof cladding. Glare from aluminium foil vapour barriers and from new metal roof and wall cladding can cause sunburn to some areas of the body not normally exposed to the sun.

Special care must be exercised when handling long-length sheeting, particularly in wet or windy conditions.

If the work is interrupted for any reason, or at the end of the workday, all loose sheeting and incomplete sections must be adequately secured against possible movement by wind.

Loose packs or loose sheets that have not been securely fastened must not be walked on.

*When cutting metal with power equipment, eye protection must be used.*

*Gloves should be provided as personal protective equipment (PPE), and are an option for workers learning to handle sheet metal, however as experienced roofers often regard them as a hazard, they are not required unless expressly requested by the roofing supervisor or person in authority.*

*Reroofing presents a number of personal hazards. The condition of old metal or any other type of roof cladding cannot be ascertained until a detailed inspection is made. This should first be done from underneath, however, all translucent, asbestos, and fibre sheets should be regarded as brittle and safety precautions taken.*

*A booklet entitled 'Guidelines for the Management and removal of Asbestos' is available from Worksafe.*

Translucent sheeting is not designed as a trafficable roof and it must not be assumed that a worker can stand anywhere on translucent sheeting.

Some owners paint over translucent sheets or skylights to remove glare, and this is not always obvious when viewed from the top of the roof. These sheets present a safety hazard, which should be investigated before re-roofing commences.

If the sheeting is too wide for a worker to cross safely, a short metal sheet should be temporarily secured over the translucent sheeting further than 2 m back from the edge of the roof.

Footwear should be in good condition, as worn footwear or loose or torn clothing can be a self-induced hazard, for which the worker himself is to blame. The weight should be evenly distributed on the soles of the feet without concentrating it on the toe or heel, and be placed in the pan of the roof cladding. When this is not possible the weight should be spread evenly over two ribs. See 13.6 Walking On Roofs.

Roof cladding is tested to a static load of 1.1 kN, which equals 112 kg and is meant to represent a worker carrying tools. It is therefore unlikely that a roof worker weighing more than 90 kg could avoid damaging a roof, because of the dynamic nature of the task.

Site supervisors should be made aware of the weight of everybody requiring access to the roof and should recognise that no two people should stand closer than 2 m from each other withing the same purlin spacing.

Tools should be hoisted up in a bucket when at the top of the ladder.

Workers should be aware of the added danger of climbing a ladder initially to secure it at the top . A second person should secure the ladder at the bottom while this is achieved.

**A ladder that extends less than one metre above the roof gutter, does not provide sufficient security for access, and alternative arrangements must be made. Carrying equipment up a ladder must be limited to small items that still allow both hands to grip the rails.**

*Inspections of roofs are sometimes made by persons other than workers, such as owners, architects, and engineers who are not conversant with safety requirements for working at height. It is a 'Duty of Care' of the Supervisor or person in authority to point out the specific hazards on the site, and to provide the safety equipment necessary to carry out their required tasks.*

Workers taking medication without notification or who have ingested alcohol or other drugs are at risk when working at height. Because their actions place other workers at risk as their balance and judgment may be impaired, this is sufficient cause to dismiss a worker from the workplace or worksite.

## 13.1.10 Safety Mesh

**Safety mesh, when designed and installed to comply with the requirements of the Health and Safety in Employment Act 1992 and the Regulations of 1995, is accepted as a fall protection barrier. It provides a double role, both for safety and as a support for underlay or insulation depend ing ent on its position within the structure.**

The NZBC durability requirement for safety mesh is 50 years and covers the total safety mesh system, including fastenings.

To comply with AS/NZS 4389:1996 safety mesh is required to be constructed from galvanised welded steel wire with a minimum diameter of 2 mm and a minimum tensile strength of 450 MPa. The grid spacing must be 150 mm longitudinally and 300 mm transversely, with a 5 mm leeway in either direction. Other materials are deemed to comply if they pass the test requirements of the standard.

In corrosive, severe marine and industrial atmospheres, safety mesh must be protected by the application of a U.V. stabilized protective coating as required by AS 2312: 2002 and the mesh must be free of sharp edges and burrs that may cause injury to the handler or installer.

The mesh joins and the connections to roof members must withstand the same point loads as the roof cladding, and the rectangular apertures resulting from the lapping and joining of longitudinal strands must have the same orientation and must not be larger than those of the mesh.

The mesh must withstand an impact test. The test load sandbag must not penetrate the mesh during or after impact and a 350 mm sphere must not pass through any part of the test specimen.

The safety mesh must be fitted under the roof sheeting so that it rests upon the purlins, battens, or rafters and so that the transverse wires are closest to the roof cladding. When installing safety mesh or hexagonal wire netting, workers must use scaffolding or fall protection equipment as described in 13.1.3 Working At Height.

One acceptable fixing method is first to position the rolls of mesh on mobile or other suitable scaffolds either side of the roof and then to take a continuous rope across the ridge to pull the mesh on top of the purlins across the roof.

The mesh must not be used as a work platform and is not safe until it is tied-off at each end as described and shown in 15.1.10 Timber Fixing and 13.1.11 Steel Fixing.

The longitudinal wires, parallel to the direction of the corrugations of the roof sheeting, must be on top of the purlins, and the transverse wires at right angles to the direction of the corrugations must be on top of the longitudinal wires.

Protection must be provided to GRP, light gauge or soft metal roof cladding between the mesh and the cladding to avoid marking or damage by expansion or by walking traffic.

The joins between adjacent lengths of mesh must be side lapped by one mesh spacing and if the purlin spacing exceeds 1.7 m intermediate tying, twitching or stapling with 2 mm wire is required.

Safety mesh is accepted as a fall protection barrier if it is constructed :

- of galvanised welded steel wire with a minimum diameter of 2 mm;
- using wire strength of 450 Mpa;
- with wires spaced 150 mm longitudinally and 300 mm transversely; and
- with the transverse wires closest to the roof cladding

Safety mesh must be tied off to purlins as shown below in 15.1.10 Timber Fixing and 13.1.11 Steel Fixing.

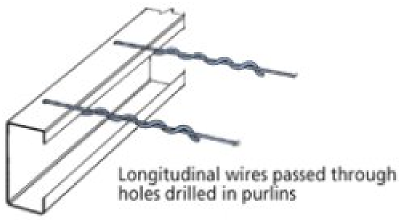
## 13.1.11 Steel Fixing

When attached to metal purlins, the longitudinal wires of the safety mesh must be passed through a hole drilled in the top of the purlin and tied off with at least four full turns around the same wire. See 13.1.11A Longitudinal Wires Run Through Steel Purlin.

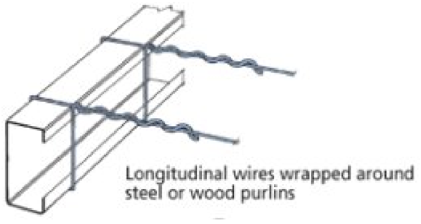
Alternatively the longitudinal wires of the safety mesh must be passed once completely around the purlin, the tail of each wire being twisted four times around the main portion of the same wire. See 13.1.11B Longitudinal Wires Wrapped around Steel Purlin

Safety mesh must be tied off as shown below.

### 13.1.11A Longitudinal Wires Run Through Steel Purlin



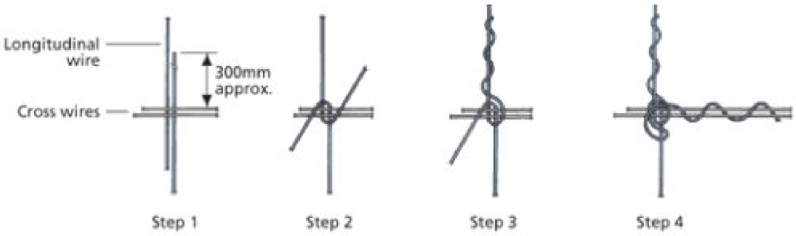

### 13.1.11B Longitudinal Wires Wrapped around Steel Purlin



## 13.1.12 Joining Safety Mesh

When joining rolls or sections of safety mesh the two transverse wires must be placed together and the longitudinaltail wires must be twisted around each other. One longitudinal tail wire must be twisted four times around the main portion of the same wire. The other longitudinal tail wire must be twisted once around the main portion of the same wire and then four times around the two transverse wires.

### 13.1.12A Joining Mesh



## 13.2 Transportation

Metal cladding should be packed and handled with care to ensure that damage does not occur during transportation. The packs of metal cladding should be clearly labeled, placed on the deck of a truck without overhanging, securely strapped to the deck, and protected from wet weather.

The load should also be well supported to stop any flexing during transport which can cause fretting, and no other cargo should be stacked on top of any metal cladding.

*Packaging for transport should be designed to ensure the protection of edges and corners against damage, to avoid fretting or abrasion due to movement and to prevent corrosion or staining of surfaces from rain or condensation. Packaging tape should be a non-permanent adhesive type as the force of cleaning can affect pre-painted surfaces and particularly the acrylic film on AZ coatings. This film is very thin, and if it is rubbed through, the surface will become patchy and unsightly.*

Slings or strops should be nylon with leather sleeves to prevent fraying or cutting and damaged slings. Single slings and chains should not be used to lift packs of cladding. Slings and booms should be approved or certified as safe and suitable for their purpose.

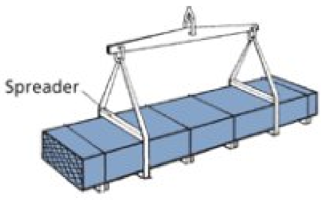
Spreader bars should also be used with slings to prevent them causing crushing damage to the edges of sheet packs. Lifting booms may be available from roof cladding manufacturers for longer lengths than 15 m.

The Regional Traffic and Land Transport Authority must approve transport of cladding in lengths greater than 25 m, and the Design Engineer should seek this approval at the building design stage.

Where transport is expected to be over long distances or rough terrain, pre-coated sheets stacked in bundles should either have a strippable film or be interleaved with paper or plastic to prevent fretting. Bundles should be supported on dunnage which lines up vertically, and top and tie downs should be provided with edge protection.

Short sheets should be packed on top of longer ones which should have end and edge protection to avoid cut end damage to the sheets below them.

### 13.2A Sling with Spreader Bar



## 13.3 Handling

It is important that due care is taken at all stages from manufacture, transport, handling, storage, installation, and final fixing to ensure that performance specifications are not impaired by damage.

The maximum bundle, weight, and sizes of sheet that can be safely and satisfactorily handled on site should be ascertained before the consignment is sent. Lifting booms should be used when lifting long length cladding using taglines for guidance.

Sheets should not be dragged either from the pile or over eaves or purlins, and each sheet from the stack should be turned and lifted directly onto the roof.

Sheets longer than 3 m should be handled by two people and carried on edge to avoid buckling.

**The packs must not be tipped or slid from the deck of the truck, and sheets must be stored away from areas where people may walk across them.**

**Soft soled shoes must be worn when fixing roof cladding to provide safe handling and to prevent damage to the coating.**

**Contact must be prevented between the cladding and any dirt, soil, cement, lime, concrete, mortar and other damaging substances.**

## 13.4
## Acceptance Of Materials

A visual inspection of the packs of roof or wall cladding should be made to check for damage before lifting the bundles off the transport vehicle. Insufficient dunnage under and between packs can cause permanent indentations of sheet surfaces.

Upon delivery, a check should be made that the correct quantity of material has been delivered and an inspection made for any strapping damage.

An inspection should be made where overtightening of bundle straps or load tension straps may have deformed the edges of the sheets. N.B. a 50 mm x 50 mm timber batten at the top of the bundle used in conjunction with the strapping system can avoid such damage.

When unpacking sheets they should be inspected for coating damage that may have occurred during transport due to coating fretting or pick-off.

### 13.4.1
### Presence Of Moisture Between Sheets

The presence of moisture should be notified immediately to the manufacturer as water damaged sheets should not be installed .

All damaged materials should be replaced and sheets exhibiting marks of mechanical damage to the profile should be rejected and the manufacturer notified.

### 13.4.2
### Colour Match

Precoated roof, wall cladding and accessories should be sourced from the same manufacturer to avoid any difference in colour matching, both for top coat and backer coats.

### 13.4.3
### Storage Stain

*All metal cladding and accessories should be kept dry before installation, including during storage on the roof structure, because accelerated corrosion or staining can occur with all metals if close stacked cladding or packing becomes wet.*
*If zinc coated nestable profiles have become wet while closely stacked, either in transportation or storage, the formation of wet storage stain or white rust is inevitable. AZ coatings are mill coated with an acrylic passivation film to give temporary protection and minimise the possibility of product deterioration. Pre-painted sheets will also deteriorate if they remain wet as moisture can cause paint softening and sheets may exhibit paint bubbling.*
*Aluminium, copper, zinc and stainless steel will all be permanently stained if left wet or if stored in this condition.*

*Translucent cladding and all metal roofing accessories with a strippable film should be protected from direct sunlight.*

*If moisture is present, individual sheets should be dried and then re-stacked to allow air to circulate and complete the drying process.*

*The extent and severity of wet storage stain is usually proportional to the length of time the sheeting has been wet.*

*In the case of superficial attack, exposure to the atmosphere and careful cleaning will sufficiently reduce surface imperfections, but heavier deposits can damage the sheets to the extent that they require replacement.*

Where it is likely that the roof or wall cladding will be stored on site for more than one week before installation, consideration should be given to ordering waterproof packaging from the manufacturer.

## 13.5 Roof Loading

Bundles or packs of roof cladding must remain banded when being lifted by a crane.

They must be placed adjacent to the portal frame and not mid-span on the purlins. Bundles must be placed so that their weight is spread over the entire area of the roof and should be positioned with the laps in the direction of laying.

Workers receiving a bundle of roof cladding on the roof must have sufficient mobility to avoid the load, and use tag lines to control the swinging of the load while it is out of reach.

Packs must be securely fixed to the structure, and part-packs must be re-fixed at the end of every day. It is the responsibility of the roofing contractor to avoid damaging the roof sheeting during its installation and fixing.

## 13.6 Walking On Roofs

It must not be assumed that it is safe or permissible to stand on any roof structure or roof cladding.

All roof cladding has access restrictions that are described in 3.6.2 Roof Traffic.

**The manufacturer of the roof sheeting must provide technical literature stating the point load limitations of the profile. Information must indicate the positions on the sheet where persons may safely walk or stand without causing damage or alternatively indicate the necessity to provide temporary walkways.**

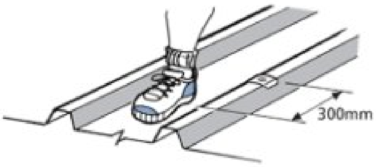
Where free access or heavy walking traffic is expected on the roof cladding, using 0.55 mm coated steel or 0.9 mm aluminium cladding should be considered.

Roof cladding on roofs with a pitch of less than 10° is particularly susceptible to traffic damage. Low pitched roofs using 0.4 mm thickness steel or 0.7 mm aluminium are considered unsuitable for foot traffic and should be provided with walkways.

The people employed for maintenance work on air conditioning plant, chimneys, painting, or fitting television aerials often don't know where to stand and consequently cause permanent deformation that can lead to ponding and eventual failure.

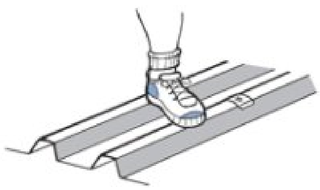
**When access to the roof is necessary after construction, workers must walk in the pan of trough-type profiles or within 300 mm of the purlin fastenings.**

### 13.6A Walking in the Pan




**If ribs are close together so that a workman cannot place his foot in the pan, his weight must be spread evenly over at least two ribs when walking up the roof, and when walking across the roof he should step close to, but not on, the fastener.**

### 13.6B Spreading Weight over two Ribs



**Translucent sheeting must not be walked on unless it is designed specifically for that purpose.**

**Where it is necessary to use the roof as a regular access way, specifically constructed walkways must be provided. Permanent walkways must be compatible with the cladding, securely fixed to the roof structure and supported clear of the roof sheeting.**

**Permanent walkways must not be made from timber, produce an unwashed area beneath them or allow the buildup of debris.**

If permanent walkways are not provided, cat ladders should be available for use at any time when inspection or repairs to the roof are necessary. They should be designed to be at least 375 mm wide, and the battens or steps should not project beyond the edges of the board or stringers.

It is the responsibility of the main contractor to inform the owner of any restrictions concerning roof accessibility.

## 13.6.1 Roof Access During Construction

**It is not safe or permitted for other trades to access the roof while the metal roof cladding is being installed. Before any person seeks or gains access to the roof, safety precautions must be taken. See 13.1 Safety**

**Safety information must be kept on site during construction and it is the responsibility of the main contractor to inform all trades that they must adhere to these requirements.**

**The main contractor must provide a prominent notice stating any limitations and the safety requirements for access. The roof must not be used as a storage area, a work platform or as support for scaffolding without total protection and planking out onto adjacent purlins.**

When other building work is required to take place adjacent to, or above a roof area such as a podium roof, no work should proceed until safety and damage precautions are in place. To prevent damage occurring from above, where plastering, concreting, welding or grinding are likely, the whole area should be protected by a temporary structure or tarpaulins.

## 13.6.2 Roof Cladding Damage

**Damage occurs more easily by standing on ribs with obtuse or flatter angles.**

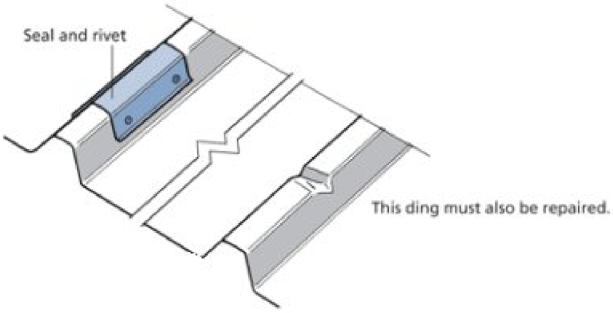
**Any permanent deformation or damage to the ribs of profiled sheeting or metal roof tiles will reduce their performance to the extent that they may leak or not meet the design load requirement. See 3.6.2 Roof**

Traffic.

Damaged roof or wall cladding sheets must either be repaired or replaced. To restore a damaged rib load capability to the original to comply with the NZBC, all damage must be repaired within prescribed limits.

For aesthetic reasons, any damage may be unacceptable. However, if the roof cladding is not visible, ribs can be repaired by using a saddle sealed and riveted.

## 13.6.2A Sealed and Riveted Saddle




It is technically acceptable to have two dings or creases on one sheet within one purlin spacing, providing two adjacent ribs are not damaged. Any greater level of damage requires the sheets to be replaced, and the person who causes the damage must report it and be responsible for its repair.

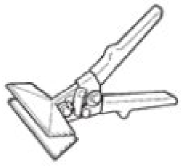
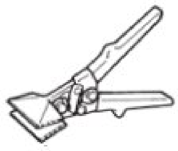
## 13.7 Completion

The roofing contractor should notify the main contractor, architects or owner when he has completed the scheduled work. If the contract is completed to the satisfaction of all parties, the roofing contractor should be released in writing from further obligations, except those included in warranties. Any subsequent damage should be the responsibility of the main contractor or owner.

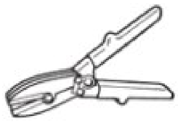
All gutters, valleys, roof channels and the roof cladding should be left clean and free from debris on completion of the work.

# 13.8 Tools Of The Trade

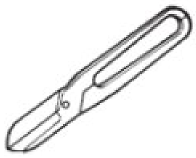
## 13.8A Hand Seamers

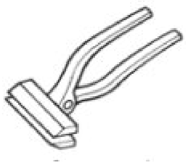
## 13.8B Crimping Tools



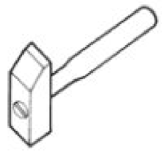

## 13.8C Shears (Straight and Curved)



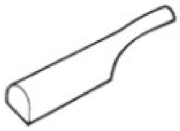
## 13.8D Seaming Pliers



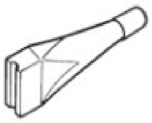
## 13.8E Setting Hammer



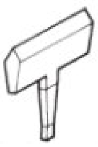
## 13.8F Hardwood Dresser



## 13.8G Hand Grooving Tool



## 13.8H Clinching Tool



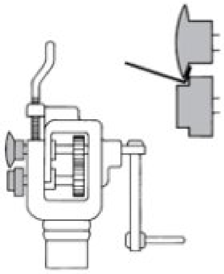
It is not possible to install metal roof cladding and accessories to acceptable trade practice without the specialised tools required to cut, fold, position and fix them in an acceptable manner, and where these tools are not available, trades-people can make their own to enable a particular joint to be made.

Some of the tools may require a vice, but most hand tools are portable and can be used on site. Portable lightweight folders are now available that can bend from 2 .000m to- 4.400m m steel of up to 0.95 mm thick.steel.
(see drawing 14.8.D)

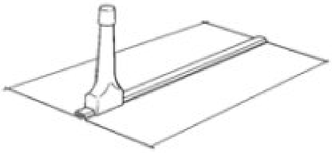
These machines can also slit the material for flashings so that they can be measured, cut and bent on-site, and fitted without the delays associated with off-site manufacture.

## 13.8I Portable Folding Machine

## 13.8J Hand Jenny Edger



## 13.8K Seaming



All metal joints that are to be sealed should be mechanically joined. Seaming is one acceptable method of joining two pieces of metal.

The two pieces are folded so each hooks into the other and then they are locked together by the means of a hand seamer or groover. (see drawing 14.8.F)

The material allowance depends onis dependent on the hook dimension, but it is usually 6 mm. That means the extra allowance for the is 18 mm, because there are four thicknesses of material.

This type of seam can be used on a flat surface or round surface.

# 14 Installation

Metal roof and wall cladding should be installed as explained in this section to comply with the NZBC and to satisfy manufacturers' warranties.

To minimize the risk of wind damage to partially clad structures during construction, it is necessary to plan the sequence and method of cladding.

## 14.1 Pre- Installation

The roofing contractor or supervisor should have seen a set of working drawings and specifications for fixing the cladding and fasteners, and have information of any special details which are specific to the project, before starting to install metal roof or wall cladding.

Before commencing major new or reconstruction roofing contracts, a pre-installation site meeting should be held attended by the architect, engineer or designer, the main contractor, the roofing contractor, and any other sub-trades whose work is associated with the roof or wall cladding contract, e.g., the air-conditioning contractor.

The purpose of the meeting is to discuss the programme, which should ensure that all possible work to be done above the roof is completed before roof cladding is commenced, all penetration framing is in position, and that access to the roof is minimised once it is installed.

A site meeting is the opportunity to discuss any discrepancy between the plans and specifications and the New Zealand Roofing Code of Practice. Any decisions departing from it should be agreed on and written confirmation signed before work begins.

Where specific details are not drawn and there are multiple replications, full-size models for sample prototyping should be made and approved, and remain on site for reference. A full-size mock-up is required to integrate components into a weathertight system that can be accepted by all parties.

Temporary access, roof protection and the provisions 5.2 Roof Drainage Design should be discussed. The responsibility for their placement and cost should be agreed between the parties.

The roofing contractor is required to have safety provisions in place that satisfy the HSE Act as outlined in 13.1 Safety before work is commenced.

The supporting structure should be inspected; the purlins and girts should be checked to see they are in a true plane and securely fixed, all trimming completed for penetrations, and any work by other trades is completed. It is the roofing contractor ' s responsibility to ascertain if there are any penetrations or protrusions through the roof or wall plane that require additional structural support or that interfere with the correct fixing of the sheets.

Access to the finished roof should be restricted and liaison with the main contractor should provide the roofing contractor or supervisor with the assurance that roof access would be controlled.

Structural steel work, treated timber or any other materials that might be incompatible with the roof or wall cladding and lead to deterioration should be painted or otherwise prevented from direct contact with the sheeting.

*If the roofing contractor is in any doubt about the requirements, he should seek clarification and receive it, preferably in writing, before commencing the job. NZBC requires that the contractor is responsible for his actions once he starts the contract. Failure to understand or follow the N.Z. Roofing Code of Practice, the manufacturer's recommendations, or the drawings or specifications will make him liable for rectification.*
*Where a warranty is required, it should be arranged with the suppliers before ordering any material. See 16.9 Material Selection*

## 14.1.1

## Setting Out And Laying

Netting support or safety mesh should be in position before roof cladding is installed, and the underlay should be placed at the same time as the sheeting. See 10.7 Underlay.

*Sheets should be ordered cut to length from the manufacturer to minimize any cutting on site. If onsite cutting is necessary, the underneath sheet should be protected from damage or marking. See 14.1.5 Cutting And Drilling*
*String lines should be used over purlin centre lines to keep fastenings in line and avoid missing the purlin with the fastener.*
*Staggered purlins require special attention and the pre-drilling of sheet stacks can be a risky option. Sheets should not be marked with black graphite pencil, as this can cause permanent etching or marking. Chalk, coloured pencils or any water-based pen is safe to use for temporary marking.*
*Where it is possible, sheets should be laid with side laps facing away from the line of sight. The local topography or obstructions can change the directional wind forces, and no reliance should be assumed that the weathering will be assisted in this manner.*
The building squareness should not be assumed and should be checked.

*The first sheet should be positioned square and straight to the end of the wall or the barge end of the roof area. The roof should be marked out so the distance between the first and last sheet to the barge boards is the same. That makes identical barge treatment on the ends of the structure possible.*
*The sheeting alignment should be checked every few sheets to prevent creep caused by stop-ending or unequal fixing. The alignment should also be checked during fixing to ensure that the sheets are maintained at their product module to avoid creeping or spreading, particularly when the building is not square.*
*The sequence of fixing should be, laps first and then the internal fixings; each sheet should be completely fixed as soon as possible.*
Where transverse laps are unavoidable, such as for curved laying procedures (see section 4.9.3.) or where two or more sheets are used to cover from ridge to gutter, they should be sealed and fastened with a minimum end lap of 150 mm.

Roof cladding end laps should be avoided below 8° by using a step flashing detail. See 8.4.4.3 Step Apron.

The minimum end lap for horizontal wall cladding should be 100 mm and be 75 mm for vertical wall cladding. A minimum overhang of 50 mm should be allowed to extend beyond the gutter or spouting, but this overhang dimension should be increased as the pitch of the roof decreases. See 14.1.4 Overhang.

Sheets should be laid square to the building or it will create a saw-tooth effect at ridge and gutter lines, which is not acceptable. Any visible deviation greater than 5 mm at the lap should be trimmed to a straight line.

Ladders should not be leant against sheeting unless precautions are taken against damage, and all cat ladders and roof boards should be padded.

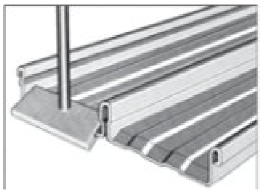
## 14.1.2 Turn-Downs (Drip Forming or Drip Edging)

All roof cladding with a pitch of less than 8° must be provided with turn-downs after the roof is fixed, using special tools to ensure water flows directly into the gutter.

Turn-Downs is recommended for all profiles at all pitches using special tools to ensure water may easily flow directly into the gutter.

As the corrugated profile cannot be satisfactorily turned down, it is not permissible to terminate this profile below 8°. See 15.1 Curved Roofs.

### 14.1.2A Profile Downturn



*Providing a profile with a downturn will provide a positive drip edge and minimise the amount of sediment build-up at the gutter line.*

Distortion should be avoided because it causes ponding and the collection of dirt, which in turn causes corrosion.

## 14.1.3 Stopends

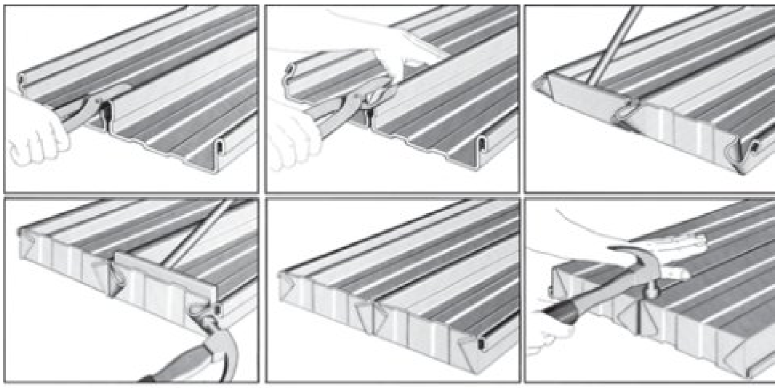
*Stop-ends are required on horizontal metal wall cladding at penetrations in exposed areas and where a horizontal sheet is cut at an angle at a gable end, and is more critical on low roof pitches or roofs in exposed positions.*
*Stop-ends for trapezoidal profiles are of two types:*

- *'dog-eared'; or*
- *'pull-up'.*

***All profiles at all pitches must have either 'dog-eared' or 'pull-up' stop-ends at the top end of the sheet.***

*It is not possible to dog-ear stop-end some profiles because most roofing profiles are manufactured from high tensile metals. In exposed areas in addition to a pull-up stop-end, it is recommended that profile closures are installed to provide an additional baffle in the following circumstances. See 8.7 Profile Closures.*
*Vertical stop-ending for sinusoidal corrugate can be done by using a 200 mm adjustable spanner, which has had the sharp edges removed. See 14.1.3B Corrugate Stop-ends.*
*A 'dog-eared' or full stop-end is made by cutting the rib back to the height of the profile so that the material can be dressed and 'wrapped around' 90°. This prevents blowback, which could occur if the stop-end was left in the original 'pull-up' position. See 14.1.3A Dog-eared Stop-ends.*
*Care should be taken when forming a full stop-end as a depression can form on some tray or wide pan trapezoidal claddings, and that can cause ponding at low pitches.*

## 14.1.3A Dog-eared Stop-ends



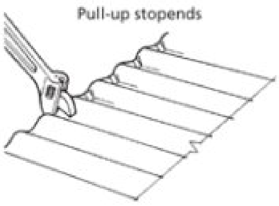
*To create dog-eared stop-ends:*

- *Slit all ribs to a length equivalent to their height.*
- *Cut away the tops of the ribs at a slight upwards angle and remove.*
- *Insert turn-up tool to full depth and turn up more than right angles.*
- *Knock dogs ears flat on a stop-end tool as shown.*
- *Ensure tray is lying flat*

*The rib height should be added to the sheet length when the material is ordered to provide an allowance for a full stop-end.*

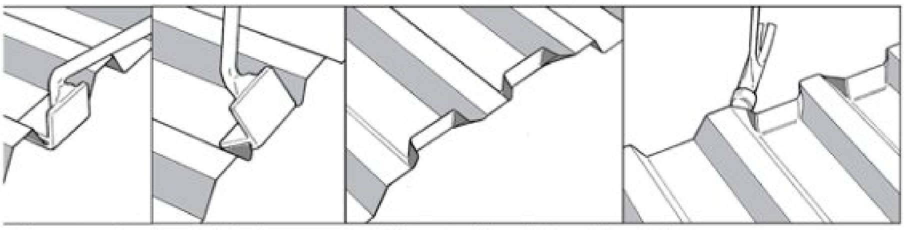
Stop-ends for corrugate should be pulled up to the full height of the profile, and on low pitches at exposed sites, additional weathering may be provided by the use of filler blocks. See 8.7 Profile Closures.

## 14.1.3B Corrugate Stop-ends




*A 'pull-up' stop-end is not cut back, but pulled up to the maximum allowable height without tearing the metal. No extra material allowance is required for a 'pull-up' stop-end.*

### 14.1.3C Pull-up Stopends

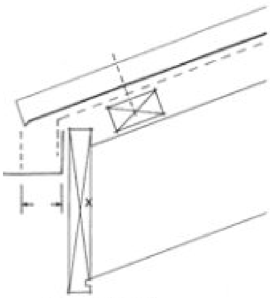



Stop-ending tools should be in good condition so that they do not mark the coating. This is particularly important when using pre-painted material.

## 14.1.4 Overhang

The length of the overhang of sheeting into a gutter or spouting depends on the pitch of the roof and the site exposure to wind and rain.
The minimum overhang for roof cladding with a pitch between 10° and 35° is 50 mm, and 40 mm is regarded as suitable for a roof above 35°. When the ends of the ribs are not baffled by a spouting and the pitch is below 10°, the overhang should be increased to 70 mm to avoid blow-back.

### 14.1.4A Minimum Overhang




In areas of high or very high wind load, additional methods are required to ensure there is no water ingress at this point. Filler blocks, end-caps and over-flashings will usually suffice, but in exceptional cases a baffle may also be needed. See 8.7 Profile Closures and 8.4.4.4 Eaves Flashing

Where a ridge vent is used, the gutter or spouting line will be a natural inlet point for air. The suction may induce air and water up the open ribs of trapezoidal metal profiles.
A step in the roof will have a larger overhang because it does not usually have a spouting or gutter to baffle the elements. Very wide gutters can expose the roof cladding in the same way. See 8.4.4.4 Eaves Flashing

The overhang into a valley also depends on the pitch. The minimum overhang for pitches of more than 12° is 50 mm and up to 80 mm in exposed areas. Pressed tiles should overhang a minimum of 40 mm.

The roofing contractor should ensure that the precautions taken for the particular profile including turndowns, over-flashings, filler blocks and end caps are sufficient, to prevent blow-back.

## 14.1.5 Cutting And Drilling

**Metal roof and wall cladding must be cut using a guillotine, tin snips, power nibbler or a power shear. Sheets must be cut with the top surface facing downwards and must not be cut on top of unprotected roof cladding.**

**Swarf resulting from cutting or drilling holes must be removed from under fastenings, laps and the cut area.**

**A circular abrasive or metal cutting saw must not be used as it destroys the metallic or the paint coating.**

Areas adjacent to all cutting, sawing or drilling operations on cladding and flashings should be protected from deposits of swarf that can be carried by the wind—such areas can include motor vehicles parked in the street below.

When nails are used, or where holes are punched, care should be taken to prevent localised distortion of the profile. Holes in roof sheeting should penetrate vertically through the crest of the ribs or corrugations except where pan fixing or side lap side fixing is specified.

Pre-drilling sheets before nailing prevents distortion. It is easier to remove swarf when the sheets are drilled on the ground before lifting them onto the roof. However, the purlin distances should be checked and aligned to within ±10 mm.

Where sheets or flashings are to be sealed, the rivet hole should be drilled before sealing, and swarf and any protective film should be removed from the lap.

Only the correct size of drill should be used for drilling rivet holes or pre-drilling roof sheets, but where oversize holes are required for washered screws, it is good practice to drill a pilot hole first.

## 14.1.6 Strippable Films

*Strippable plastic film coatings are available from the paint coating manufacturer to protect and prevent damage to pre-painted material used for roof and wall cladding and accessory products during roll forming, installation and transportation.*

It is important that all film-protected metal should be stored dry, and out of direct sunlight and the film removed as soon as possible after installation. Where laps occur the film should be removed before installation, and when drilling for fasteners the film should be removed after drilling, but before fixing.

**The protective film must never be left in a joint that is to be sealed as silicone and other sealants will not adhere satisfactorily to it.**

The film should not be exposed to UV or left exposed for more than a few weeks after installation as it may be difficult to peel off. Any film should be disposed of in an environmentally responsible manner.

## 14.2 Swarf

*Cutting or drilling operations on any metal produce fine metallic filings known as swarf. Steel swarf will rust immediately on reaction with oxygen and water to produce a stain that is very often mistaken for the rusting of the substrate. Such damage to metal cladding and pre-painted steel coatings is avoidable; it is the result of poor fixing practice or the work of other trades.*

*If swarf is not immediately cleaned from pre-painted steel building products, damage can appear either as localised rust stains or as fine scratches from swarf embedded in shoes. This type of damage will naturally detract from the performance or the appearance of the product. Non- ferrous metals also produce swarf, but as it does not rust it is not so obvious. It should, however, be removed in the same manner as steel swarf.*

*There are several different types of swarf. The most common swarf left on metal roof sheeting is that left as a result of using self-drilling screws, which consist of helically shaped coils and small chips. This local type of swarf should be regarded as a necessary part of the roofing process and can be easily removed, by regularly sweeping swarf into a receptacle with a nylon brush or using a small magnet.*

*Swarf can collect under flashings, screw heads, washers and in sheet laps, particularly with the use of horizontal cladding, and staining can arise if swarf is not removed as soon as it is generated.*

*Extra care should be exercised when fastening sheeting to structural steel because drilling heavy steel can create a large amount of swarf.*

*Power nibblers provide a clean cut but produce a metal cutout that can become embedded in the soles of footwear of people working on the roof, and it can be detrimental to the roof coatings. Nibling operations should be performed on the ground and this type of swarf should be cleaned up as it is produced.*

*N.B. – A power shear does not produce swarf.*

*Swarf produced by friction cutting or abrading equipment consists of fine metal particles, which have a large area of exposed steel, and therefore corrode very readily. It can be distinguished from drilling swarf by the 'sandy' feel of round particles, and the rust marks have a central round spot with a diminishing halo.*

*The particles generated by hole saws are also as the result of friction and are included in this category. This swarf is produced as hot particles; oxidation is rapid and they are not easily removed because they can embed themselves by melting or burning into the surface of the metal or coating.*

Friction cutting equipment by definition produces heat, which destroys the metallic and paint coating in the vicinity of the cut. This method of cutting is unacceptable and material cut in this manner is not covered by any warranty. See 4.15C Friction Cut Edge.

Friction blade or carborundum disc cutting is not permissible on metal roof or wall cladding.

*The roofing contractor will safeguard himself from any damage claim if round swarf is discovered, by not using any friction type cutting tools on site. Power shears, guillotines and hand snips do not produce swarf and in skilled hands are capable of cutting any shape required for the installation of metal cladding.*

*A common cause of swarf complaints arises because other trades have used grinding equipment in the vicinity of a newly completed roof. Wind carried swarf can contaminate large areas. Designers and other contractors should be aware of the likelihood of such damage, and project planning should include scheduling of all cutting or grinding work to be completed before laying the roof cladding.*

*Failure to do so can result in damage and the necessity for a reroof or repainting. The liability remains with the person who caused the damage and is not the responsibility of the roofing contractor.*

*Other debris that is created from the roof cladding process, including rivet stems, nails, screws, broken drill bits, tools, and used sealant cartridges left on a roof surface, can all cause rust staining.*

All debris should be removed daily from the roof cladding and gutters.

## 14.2.1 Swarf Removal

*Prevention of swarf damage is much easier than repair.*
At the end of each day, the work area should be cleaned by either sweeping with a softbristled broom or hosing down to remove all debris from the roof and gutters.

*Dew or condensation will produce rust overnight, so the swarf should be collected as it is produced. A screw gun with a magnetic bit can be useful for this purpose.*
*As swarf particles are sharp, care should be taken not to damage the surface coating by wearing clean, soft-soled shoes that do not collect swarf, dirt, and gravel. Damage can be minimised by placing a mat or sacking at the base of the ladder so that shoes can be cleaned before moving on to the roof.*
*All contractors with access to the job should follow the same rules for cleaning up, work practices, and footwear as other trades are often responsible for causing damage that is incorrectly attributed to the roofing contractor.*

## 14.2.2 Swarf Damage

*If the swarf staining comes from drilling, it is likely that the effect on pre-coated claddings will be aesthetic only and that the performance of the sheeting will not be greatly affected. This is not the case when hot swarf has embedded itself into the paint surface and is in contact with the metallic coating.*

*In weathering away by oxidation, the metallic coating will sacrifice itself to the bare steel swarf in the immediate vicinity and the life of the coating will be shortened. This situation occurs with plain AZ, ZA, and galvanised metallic coatings, where claddings are not pre-painted, and any swarf left on the surface will be detrimental to the longevity of the sheeting.*

*No cure will restore the surface to its original condition, but damage can be reduced by prompt action.*

*Mild swarf stains can be removed by sparingly applying dishwashing liquid to the immediate area, using a soft cloth. For stubborn swarf that has been left for some time and adhered to the surface, the careful use of a nylon pot cleaner may be necessary. The immediate area should be cleaned without undue pressure, as this could mar the paint surface, and the whole area should be washed down with copious amounts of water to ensure there is no remaining cleaner left on the roof.*

*The factory applied acrylic coating on AZ coatings can be easily damaged, and should not be scrubbed as it will cause a patchy darkening of the surface that will become evident in the repair areas.*

*Where extensive areas have been affected by grinding swarf, more drastic action may be required. In severe cases, the areas around the swarf should be scrubbed with a stiff bristle brush until all the swarf particles are removed. Any remaining swarf will bleed through the subsequent coating.*

*If the affected areas show through to the metallic coating, these should be primed first, and the total area of the visible roof cladding should be over-painted with two coats of acrylic paint. Air-drying paints weather more rapidly than factory applied coatings and quickly display colour changes, so patch painting is not a recommended option. Minor scratching or abrasions should be left alone and not be painted for the same reason.*

## 14.3 Fasteners

*A fastener is a mechanical device for securing cladding and components to a structure or to another component, this definition includes nails screws, clips, and bolts.*
*Fasteners are also commonly known as fastenings and fixings, which is confusing because a fixing describes the result achieved by the use of a fastener by a fixer, and the verb to fix and to fasten are interchangeable.*
*The strength of a fastener relates to the mechanical properties of the fastener alone, whereas the strength of a fixing relates to the minimum value of pullout, pull-over, washer inversion and strip-out capacities. These values are obtained from the strength of the member (e.g., purlin) into which the fastener is secured and also of the component (e.g., cladding) that is being restrained.*

The performance data published by the fastener manufacturer and that described in AS 3566 relate to the product only, and should not be used for design purposes. Values assessed by the manufacturer do not necessarily follow the method required to obtain applicable design load values.

The design load required for metal cladding and accessories is calculated for the joint and not the fastener.

Because the durability of a fastener will determine the long-term performance of the metal cladding, the fastener and its coating should be compatible and suitable for the environment.

### 14.3.1 Primary Fasteners

Primary fasteners are those that attach roof or wall cladding to the building frame. Because they are relied on for structural performance, they should be capable of withstanding the design withdrawal load specific to the site and their location on the building. They should be able to withstand all loads applied to the sheeting, including those due to expansion, and remain watertight.

Fasteners should not be overdriven as that can damage the sealing washer, distort the roof cladding, and cause leaks. Screw fasteners should not be overdriven as this can affect the pullout values and cause strip-out when fastening to light gauge purlins or battens.

The shank diameter and thread type of the fastener will determine the withdrawal loads into either timber or steel, so the designer or contractor should ensure that the fastener complies with the requirements of 3.12 Fastener Performance.

The number of fasteners per square metre required to resist all wind or other loads on a building depends on the type of fastening.

Primary fasteners for timber consist of nails and screws with varying diameters , but their performance should be individually assessed.

When using light gauge metal roof and wall cladding the size of the head will determine the performance of the sheeting under load, as the calculation of pull-over strength assume that either the screw or the nail washer has a minimum head size of 12 mm. See 3.12.2 Pull-over Values.

Fasteners with heads smaller than 12 mm, such as wafer heads and proprietary screws for fixing miniature profiles used without metal or sealing washers, should not be regarded as a substitute for primary fixings for metal claddings. These fixings can be used with different fastening patterns to those in 3.16.4 Fastener Patterns, but the pull-over load should be determined from tests and should not be confused with the pull-out values provided by the manufacturer.

The fastener to connect battens or purlins to the structure is a primary fastener, and if the roofing contractor is responsible for attaching these members, the wind uplift load should be determined. See 3.7 Wind Load and 3.16.1 Purlin-Rafter Connections.

## 14.3.2 Nails

**Only enhanced shank nails with metal and sealing washers must be used as primary fasteners to secure metal roof and wall cladding. Smooth shank nails must not be used.**

*Nails are usually hand driven except when used for fastening clips for secret-fix or fully supported roof or wall cladding, when air or gas operated nail guns may be used.*

The holding power of a nail in timber depends on the type of timber and its moisture content, not only when nailed but also in service. Nails can back out during its service life if the moisture content is more than 18%; screws should be used instead of nails if it is higher.

*The traditional New Zealand roof fastener was until 1980 the "Lead Head", a flat-headed smooth shank steel nail with a lead head cast on it. Lead heads often 'backed out' causing leaks, which has led to the mistaken belief that nails have to be "hammered home".*

*Spiral Shank nail fasteners rely on the frictional grip of the spiral shank to stay in the timber. The holding power of a spiral shank exceeds that of a smooth shank by two to three times. The seal produced by a resilient washer bonded to a metal washer requires only 50% compression to produce a seal.*

Spiral shank nails should not be over-driven or the washer seal will be impaired. Spiral Shank nails used to fix metal roof and wall cladding should have a hot dipped galvanised coating of 70 μ in thickness. Potentially rust-causing damage to the head from hammering can be minimised by using a nylon- faced hammer.

Only factory paint coated nails and washers should be used with pre-painted cladding. Galvanised nails should only be used with zinc or AZ coated sheeting.

Painted stainless nails can be used for fastening:

- non-ferrous and plastic roof and wall cladding in severe and very severe environments;
- when other exotic coatings are used.; or
- when unusual corrosion conditions exist.

Only paint coated stainless nails and washers may be used with paint-coated aluminium roof and wall cladding. Factory coated stainless steel nails and washers are available to colour match cladding for environmental conditions where zinc coated fasteners would not perform their function for the 15 years required by the NZBC, or where aesthetic appearance is paramount.

Acrylic paint should not be applied directly to galvanised nails or washers without a suitable primer.

The nail should always be hammered in at right angles to the roof and if the purlin is missed no attempt should be made to "skew" the nail. The hole should be sealed with a rivet and neutral cure sealant, or the sheet should be replaced.

Minimum penetration of nails into timber must be 40 mm.

## 14.3.3 Screws

*Self-drilling screws with a piercing point and a thread suitable for drilling into timber with a hexagon head are designated as Type 17. A screw gun can provide sufficient torque for a type 17 screw to pierce metal roof cladding profiles and thread themselves into soft wood, but hardwoods may require a pilot hole.*

### 14.3.3A Screw Points

Drill point

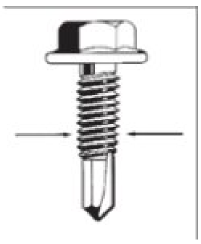
Pierce point

### 14.3.3B Screw Thread Types

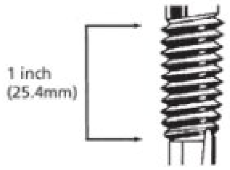
| Gauge | Diameters Nominal | | Threads Per Inch TPI | | | Head |
|---|---|---|---|---|---|---|
| | Shank | Thread TPI | Thread Type | | | |
| | mm | mm | A | B | C | |
| 6 | 2.5 | 3.5 | | 20 | 32 | Pozidrive/Philips |
| 8 | 3 | 4.2 | | 18 | 32 | 1/4" HEX |
| 10 | 3.5 | 4.8 | | 16 | 24 | 5/16"HEX |
| 12 | 4.1 | 5.5 | 11 | 14 | 24 | 5/16" HEX |
| 14 | 4.8 | 6.3 | 10 | 14 | 20 | 3/8" HEX |

*Coarser threads (less than 17 TPI) are used to fix roof and wall cladding. However, a finer thread, known as metal thread, is used when fixing to steel thicker than 2.4 mm. Different thread configurations are available for special applications and some shanks are provided with a gripping thread at the top of the shank.*

### 14.3.3C Screw Gauge



## 14.3.3D Threads per Inch (TPI)




All fasteners must be easily identified by a code stamped on the head to identify the manufacturer and the coating class. The size, type, length, head type and the standard to which the fastener is manufactured must be identified on the packaging and in the manufacturer's literature.

When counter battens are used, and the primary cladding fastener does not always penetrate the structure, the fastener used to secure the counter batten to the structure also becomes a primary fixing.

When solid sarking, insulation or decking is interposed between the cladding and the structure, the design uplift force on the decking should be resisted by the total number of fasteners per square metre, multiplied by their individual capacity. (See 3.12 Fastener Performance)

Screws that are to be used as a structural fastener, such as in a stressed skin roof design or structural purlin/rafter connection, should be made using a screw gun with an adjustable torque setting to ensure consistency of fastening.

Stainless screws should be driven with a new driving socket so that steel smear from a used or worn socket head does not contaminate the stainless steel screw head. Alternatively, a stainless socket should be used.

While the common roofing screw is a Class 4 coated steel screw, stainless steel and aluminium are alternatives. (Also see 8.7.3 Secret Fixing Clips)

The 14 gauge aluminium screws available are suitable for rib fastening of profile metal cladding into timber purlins and 12 gauge are suitable for pan fixing. They require pre-drilling into timber and are not suitable for fixing into steel. Care should be taken not to over-drive aluminium screws as their shear strength is less than steel.

Stainless screws are available in Grades 304 and 316, but only 304 should be used for fixing aluminium cladding. Grade 304 is suitable for very severe environments, provided the screw shank is isolated by an oversized hole and a load spreading washer made from 445M2 stainless steel is used with an EPDM sealing washer.

## 14.4 Secondary Fasteners

Secondary fasteners are used to attach cladding sheets to one another, to transfer loads and to provide side lap sealing. They should be used in conjunction with primary fasteners to comply with the site wind design load. Because side and end laps are subject to shear loading caused by expansion and differential movement, the wind load and point load requirements will not be met unless secondary fasteners are used.

Laps on purlin spacings over 1.2 m should be stitched at mid-span with coarse thread stitching screws or self-sealing 4.8 mm aluminium blind rivets. This applies when fixing self-supporting ribbed metal profiled cladding, but not self-locking profiles.

*Screw fasteners where the thread stops short of the head, ensuring that stripping out cannot happen, are available for side lap fastening.*

### 14.4.1 Rivets

*The rivets used in fixing roof and wall cladding are 'blind' or 'pop' rivets that can only be fastened from one side. Sealed type rivets are recommended.*

Zinc-plated steel rivets should not be used for roof or wall cladding in New Zealand because they do not meet the durability requirements of the NZBC. Similarly, rivets with a 3.2 mm diameter do not have the shear capacity required for fixing metal roof and wall cladding.

Rivets are subject to pull-over failure in tension because the head sizes are usually smaller than screws. It is necessary to use more rivets than screws to fasten the same joint because washers provide increased pull-over capacity for screws.

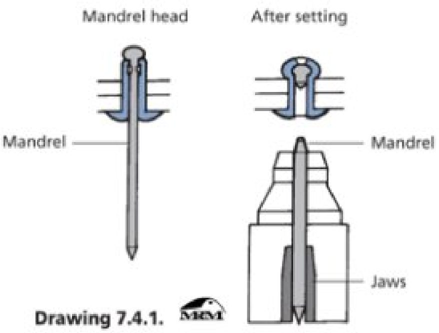
The correct drill size, 0.1 mm larger than the nominal rivet diameter, should be used when drilling metal for blind rivets.

#### 14.4.1A Rivet Hole Size

| RIVET DIAMETER | DRILL SIZE |
|---|---|
| 4.0 mm | 4.1 mm |
| 4.8 mm | 4.9 mm |
| 6.3 mm | 6.4 mm |

*Rivets should not be spaced less than 3d or more than 20d to minimise distortion ; "d" represents the diameter of the rivet.*

## 14.4.1B Pop Rivet




## 14.4.1C Minimum Strength Capacity: Blind Rivets

**Minimum shear and axial tensile capacity (strength) of break mandrel blind rivets**

| Code | Drill size | Nominal diameter | | Nominal head diameter | Minimum shear capacity (strength) (kN) | | | Minimum axial tensile capacity (strength) (kN) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | mm | Inches | mm | mm | Al | M | S/S | A1 | M | S/S |
| 5 | 4.1 | 5/32 | 4.0 | 8.0 | 1.3 | 2.5 | 3.0 | 1.62 | 3.24 | 3.8 |
| 6 | 4.1 | 3/16 | 4.8 | 9.5 | 1.6 | 3.7 | 4.4 | 2.3 | 4.63 | 5.5 |
| 8 | 6.5 | 1/4 | 6.3 | 12.7 | 3.2 | 6.48 | 7.8 | 4.26 | 8.56 | 9.72 |

*Al = aluminium alloy 5154, 5056 and 5754, with carbon steel mandrel.*
*M = nickel-copper alloy (Monel) with carbon steel mandrel.*
*S/S = 300 series stainless steel with carbon or stainless steel mandrel.*

The values in 14.4.1C Minimum Strength Capacity: Blind Rivets should be multiplied by ø, the reduction factor = 0.65 for shear and 0.50 for tilting and bearing.

## 14.4.2 Monel Rivets

*Monel Rivets have been used to fix galvanised steel flashings for many years. In theory, corrosion of the galvanised steel could be expected, because zinc and monel are far apart on the galvanic scale. This does not often happen in reality because of the natural passivation of monel in normal environments, and because the area of the rivet (the cathode) is small compared to the sheeting (the anode).*
*The copper content of monel is low, and being alloyed with nickel, it gives good performance in most environments. In an aggressive marine or industrial environment, a barrier coating is needed to avoid any likelihood of corrosion. N.B. Using monel rivets with Zinc/Aluminium coating may compromise the manufacturer's warranty.*

## 14.4.3 Aluminium Rivets

*Aluminium Rivets are compatible with zinc or AZ coated steel but have a shear performance of less than half that of monel or stainless steel rivets. They are available in open and sealed types.*

**Because of the high shear expansion forces developed in roof cladding and flashings, the minimum diameter of aluminium rivets used in roof or wall cladding must be 4 mm ( 5/32 ).**

## 14.4.4 Stainless Steel Rivets

Stainless Steel rivets have been used historically in a similar manner to monel, but in aggressive marine or industrial environments, a separation barrier should be used between dissimilar metals.

## 14.4.5 Spacing

*Spacing and size of rivets is related to the likely stress imposed at the connection, so as the strength of the rivet increases, the spacing may also increase.*
*The following maximum spacings should not be exceeded when sealing and joining gutters or cappings.*

### 14.4.5A Rivet Spacing

| Diameter | Spacing |
|---|---|
| 4 mm (5/32) | 50 mm |
| 4.8 mm (3/16) | 60 mm |

*N.B. This equates to approximately 12d; "d" = diameter of the rivet*

## 14.4.6 Fastener Frequency

*The fastener frequency for fixing roof and wall cladding is determined by the wind uplift load for the particular site and the gauge of the cladding. In low wind load areas, the frequency may be determined by a sufficient number to prevent the cladding from 'flutter' or noise associated with the relative movement of the cladding against the structure.*

*A uniform linear fastening pattern should be used to resist wind uplift loads; however, additional staggered fastening may be necessary to avoid noise and flutter.*

*Nailing and screwing patterns are shown in 3.16.4 Fastener Patterns, and the pullover values in 3.12.2 Pull-over Values.*

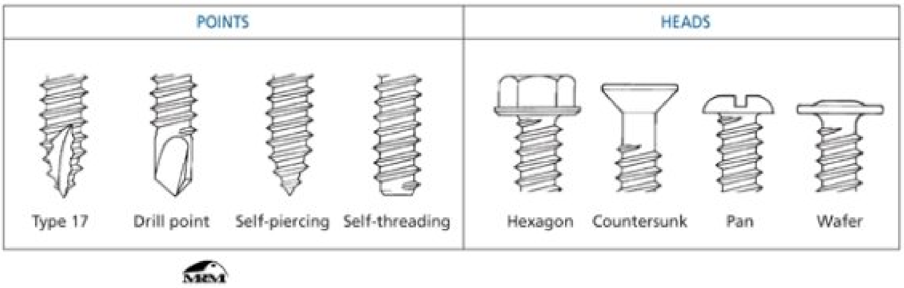
*The primary fastener frequency should not exceed 600 mm, and where this is not possible a secondary fastener should be used at closer spacings. Where fixing is not provided for primary fasteners, secondary fasteners such as stitching screws, type 17 and 4.8 mm aluminium rivets can be used, providing their number and frequency equates with the equivalent primary fastening for the wind design load.*

# 14.5 Fixing

## 14.5.1 Crest Fixing

*Crest fixing is the most common type of fastening of roof cladding in New Zealand.*
*For fixing into timber a Type 17 self-drilling fastener that has a pierce point slot thread is used, which penetrates the roofing metal and then threads itself into timber.*
*The embedment into soft wood must be a minimum of 30 mm and greater than 6 times the screw thread diameter.*
*For fixing into steel, a self-drilling fastener with a drill point of a diameter suitable for the tapping size of the fastener is used. Extended drill points are available for drilling up to 12 mm thick steel and the pitch spacing of threads should be increased as the steel thickness decreases. See 14.3.3B Screw Thread Types*
*Steel embedment should be 5 to 6 mm beyond the drill point with a minimum of 3 threads beyond the drill point.*
*Screws are specified by gauge, TPI (threads per inch), and length.*
*Self-threading screws require a pre-drilled hole in the cladding and structure. The tapping size drill diameter is determined by the TPI and gauge of the fastener.*
*Both self-drilling and self-tapping screws can have different points, TPI, and heads to suit the particular requirements of the connection.*

### 14.5.1A Screw Points and Heads




## 14.5.2 Pan Fixing

*Pan or trough fixing is commonly used for wall fixing although it is not widely used for fixing roof cladding in New Zealand. Pan fixing is common practice in Europe and offers an economical alternative to rib fixing.*
Pan fixing can be used for roof as well as wall fixing provided certain fixing conditions are met:

1. Light coloured roofs are limited to 12 m, thereafter with sliding washers and crest fixed.
2. Dark coloured roofs are limited to 8 m, thereafter with sliding washers and crest fixed.
3. If the insulation is laid close to the roof cladding, deduct 4 m of pan fixing from the above.
4. If the ceiling is insulated, the roof cavity should be vented by a ridge ventilator or other permanent vents.
5. Metal roofs that are not post painted should be regarded as dark coloured due to the oxidation and change in colour and surface over time.

6. Translucent fibreglass sheets can be pan fixed for 8 m then crest fixed with sliding washers for 4 m, limited to a maximum of 12 m.
7. Fasteners should be a minimum of 12 x 20 mm self-drilling for steel purlins and 12 x 40 mm for timber, both using a 25 mm metal and sealing washer.
8. All fasteners should be driven snug tight with a torque driver or depth locator.
9. Fasteners should be placed within 50 mm of the rib of the sheeting but allowing 25 mm clearance for water egress.

N.B. The pullover design values established by testing for pan fixing are more than twice those for crest fixing.

All sheets should have full bearing on all purlins that they cross to ensure a positive seal. Care should be taken to fix at right angles to the roof, and purlin flange alignment is critical if purlin creasing is to be avoided.

Corrugate and symmetrical profiles should not be pan fixed for roof cladding.

*Pan fixing of roof cladding, is used in USA and Europe because of its cost and efficiency; the pullover values are increased, and it provides a much more effective shear diaphragm for cladding lengths up to 8 m.*

## 14.5.3 Expansion Fixings

A limited amount of movement between the fastener and the cladding can be provided with an oversized hole for the fastener. When a greater amount of expansion is required, sliding fixings are necessary to allow for expansion and contraction. (See 7.3.2A Favourable Circumstances for Controlling Expansion)

There are two main types of sliding fixings.

- Sliding Washers
- Sliding Roofs

### 14.5.3A Sliding Washers

Sliding washers are used where the sheet and the fastener are separated by a material with a low friction coefficient, such as Teflon, enabling them to move independently in elongated holes. N.B. The seal should be made between the roof cladding and the washer by placing the sliding face (Teflon) upwards and the sealing face down onto the cladding.

**Where an oversized or elongated hole is used, the sealing washer must be wide enough to seal the hole.**

### 14.5.3B Sliding Roof

*Sliding Roof is where a clip is securely fastened to the structure, and a longitudinal groove cladding profile provides clearance for expansion and contraction.*

## 14.5.4 Lap Stitching

**All roof or wall cladding, except self-locking and fully supported profiles, must be lap stitched at midspan when purlin spacings exceed 1.2 m.**

**Lap-fixings must be coarse thread stitching screws with a neoprene washer or 4.8 mm diameter aluminium Bulb-Tite rivets.**

Without lap stitching the wind and point load performance will not comply with the load span graphs in 3.16.5 Wind Load Span Graphs

## 14.6 Installation

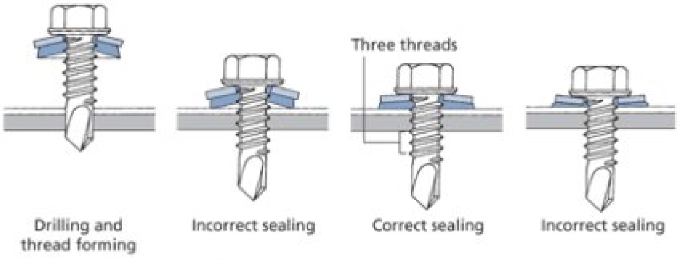
### 14.6.1 Driving

Self-drilling screws used in steel require the correct thread type and length; it should have three threads extending past the fastened metal as shown in *drawing 7.6.1.A.* The drill should have finished drilling into the structural member before the thread engages.

When driving pan fixings where the fastened material and the material fastened into are the same thickness, the fastened material should be pre-drilled.

*Pre-drilling is also necessary when multiple layers are fastened. Different headed fasteners are used for different purposes, but the driving bit should be capable of providing sufficient torque to ensure the fastener is not underdriven. Hex head screws provide better torque than recessed heads, but square drive screws are better than other recessed head screws.*

#### 14.6.1A Depth Setting




**Drawing 7.6.1.A.**

The correct depth setting on a screw gun is provided either by the depth gauge or by a clutch torque adjustment, and an adjustment should be made every time a different screw or material thickness is to be drilled. Resilient washers under fastener heads will only seal properly with the right adjustment.

Experienced operators can, in most instances, drive screws correctly by using a variable speed screw gun. When fastening into light gauge structural components, however, the cladding should be predrilled to avoid stripping out.

Driving screws into timber, 'part' the fibres rather than cutting them which provides a self-locking action against withdrawal.

Impact drivers do not drive in this manner and are therefore not recommended for driving roofing screws.

The rolled thread on crest fasteners longer than 25 mm stops before the head, whereas a shorter length screw has the thread rolled up to the head. This means a clearance hole is provided for the material being fastened when driving a crest fixing, and the only driving torque required is that to fasten into the structural member. When driving a pan fixing, both the material being fastened and the structural member should be threaded together.If they are not sufficiently clamped, broken screws or strip-out will occur.

Common problems encountered when fixing roof or wall cladding with Type 17 or self-drilling screws are usually the result of incorrect screws, incorrect screw gun or adjustment, or user error.

The drill point travels approximately ten times slower than the thread engagement speed when drilling steel; if the drill point is not long enough to penetrate both thicknesses of material, the screw is likely to shear.

### 14.6.1B Troubleshooting Driving

| Problem | Solution |
|---|---|
| **Difficult to start** | Hold screw gun at right angles to the cladding.<br>Check rotation of screw gun.<br>Apply greater force. |
| **Screw wobbles and is difficult to start** | Wrong driver bit.<br>Check rotation of screw gun.<br>Drill point malformed. |
| **Screw heads break off** | Incorrect clutch or depth adjustment.<br>Drill bit not long enough.<br>Too small a screw for the material thickness. |
| **Threads strip out** | Incorrect screw thread for material thickness.<br>Incorrect clutch or depth adjustment.<br>Material not pre-drilled. |
| **Drill point breaks** | Clamp material together if there is an air gap.<br>Pre-drill multiple plies.<br>Check rotation of screw gun.<br>Drill bit not long enough. |
| **Driver bits break** | Incorrect bit (Phillips or Posidrive).<br>Incorrect adjustment. |
| **Sealing washer squashes out** | Incorrect adjustment.<br>Too much force. |

## 14.6.2 Tools

*Power screwdrivers should be provided with an adjustable depth setting or a torque setting clutch to avoid over-driving. Ideally, the driver should have variable speed.*

### 14.6.2A Recommended Drilling Speeds

| MATERIAL | SCREW | RPM |
|---|---|---|
| Steel into Steel | Drill Point | 2500 |
| Steel into Timber | Pierce Point | 1500 |
| Steel into Steel (,0.9mm) | Drill Point | 1000 |
| Stainless Steel | Drill Point | 800 |
| Any self-tapping | Self-threading | 300 |

*To avoid damage to the head of the fastener or coating, sockets should be well-fitting and in good condition, and drive bits should be the correct size (2 or 3) and type Phillips, Pozidrive or square drive.*
*When drilling 3 mm steel the actual drilling takes seven seconds, but the threading takes less than one second, so the reaction is immediate and should be automatic to avoid damaging the roof cladding.*
*When drilling thick steel, elongated drill points are necessary to avoid breaking the screw. Alternatively, a self-threading screw can be used with a pre-drilled hole suitable for the gauge and thread of the screw.*
*When fasteners are used to secure to a metal less than 0.9 mm thick strip-out can occur if the screw is driven at too fast a speed, even at a low torque setting.*

## 14.6.3 Modes Of Failure

*The cladding/structure connection can fail for several reasons.*

*1. Pull-over : where the service load causes the sheet to be pulled over the fastener head due to:*

- *not enough fasteners;*
- *no load spreading washers;*
- *incorrect washer diameter or shape; or*
- *insufficient washer thickness.*

*2. Pull-out : where the fastener is pulled out of the support member due to:*

- *i not enough fasteners;*
- *insufficient penetration;*
- *incorrect choice of type of fastener; or*
- *failure to install correctly .*

*3. Thread strip-out because:*

- *the fastener is over driven;*
- *the predrilled hole is too large;*
- *the screw gun depth gauge is incorrectly set; or*
- *tilting and bearing failure caused by differential movement .*

*4. Backout: where the fastener works loose due to:*

- *not enough fasteners;*
- *incorrect selection of thread type;*
- *timber moisture content over 18%;*
- *mechanical vibration of the structure; or*
- *predrilled hole too large.*

*5. Shear of fasteners:*

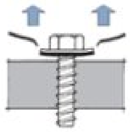
- *not enough fasteners;*
- *too small a screw diameter; or*

- *differential movement between sheet and support.*

*6. Corrosion from:*

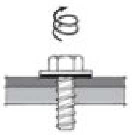
- *incorrect fastener material selection for the type of external environment;*
- *incorrect fastener material selection for the type of internal environment;*
- *damage when the nail or screw is driven; or*
- *using non-compliant fasteners, see AS 3566.*

## 14.6.3A Pull-Over

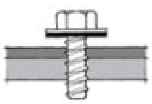


## 14.6.3B Pull Out

## 14.6.3C Thread Strip Out



## 14.6.3D Back Out



## 14.6.3E Fastener Shearing

## 14.7 Re-Roofing

*When roof cladding reached a stage that maintenance may cost more than a renewal, a number of decisions will determine if the renewal will require a building consent.*
*If the material is 'comparable' the contract may not require a consent, but if the decision was made to renew 0.55 mm roof cladding with 0.4 mm material or a different profile it would not be regarded as comparable or "like with like". In this instance, the purlin spacing would have to be changed if it did not comply with the existing wind load requirements.*

*It is, therefore, recommended that either a consent be applied for or inquiries are made with the BCA or Building Certifier before proceeding with any re-roofing.*

**Before any existing roof cladding is removed, the surface has to be inspected to ensure it is sound and does not represent a hazard as outlined under safety in section 14.**
**The provisions for working at height must also be in place before any cladding is removed.**

**All underlay must be renewed because it is possible that the new cladding material could last 50 years with appropriate maintenance. The underlay support must be inspected, and any material with visible deterioration must be removed and replaced. All old wire netting and staples must be removed before installing new materials. Purlins must be free of debris and other materials, if not the purlins must be turned over or renewed.**

**Netting must not be used when re-roofing with aluminium cladding; use self-support underlay or alternative underlay support, such as durable synthetic string or strapping.**

**Flashings must also be renewed when there are different materials involved.**

*Some older buildings were built with a pitch or purlin spacings that do not comply with the current requirements or the manufacturer's conditions of warranty. The current requirements should be met for consent or before a warranty can be issued. When re-roofing an old tile roof with profiled metal cladding, the battens should be replaced and new purlins installed in compliance with the NZBC.*
*The roofing contractor is responsible for ensuring that the owner and occupier are fully aware of the work programme. He should advise them to take precautions against temporary water ingress due to the removal of cladding or flashings.*

*Some factory or essential services may require the roof renewal to be completed outside normal hours or at night. In such cases, the police, alarm companies or other services may have to be notified.*

*It is the roofing contractors responsibility to make the owner and occupier fully aware of such arrangements and assign the responsibility.*

*If the old roof or wall cladding has been nailed, the contractor needs to take special care not to damage the ceiling. For this reason screw fixing is better practice.*

*'Patching' with slip sheets is not a recommended practice, because:*

- *it produces transverse laps;*
- *it can mix metallic and painted coatings;*
- *it is only a short term solution; and*

- *it is visually unattractive.*

*The removal of all material, flashings and other debris is the roofing contractor's responsibility unless otherwise assigned.*

## 14.8 Translucent Sheeting

Translucent sheets should be fastened in the same way as metal cladding, except that extra or special fixings are required because plastic sheeting deflects more.

A different depth or screw gun torque setting may be required to avoid over tightening and subsequent distortion around the fixing. Because of their different rates of thermal expansion, plastic and metal sheet fixings should be fastened through oversized holes. Support for plastic sheeting is obtained from the metal sheeting for downward loads and span-breakers for uplift loads. See 14.8.4 Midspan Supports.

**All plastic roof light sheets must be laid on top of the metal sheeting at both edges.**
**Side laps must be fixed at a maximum of 600 mm centres (fixing details in 14.8.1 Side-Lap Fixing) and are required to be sealed where the roof pitch is less than 10° and in high wind design load areas.**

**Oversized holes and load-spreading washers must be used when fixing roof lights to metal sheeting. All plastic roof lighting must have pre-drilled intermediate side lap fastenings with oversized holes on all spans larger than 1.2 m. See 14.8.1 Side-Lap Fixing**

To avoid stress, roof lights should always be fixed starting from one end and fixing the intermediate purlins before doing the ends.

Deflection limits should be placed on the performance of plastic sheeting to ensure longevity and to avoid incremental failure due to flexing at the fixing points. This can be done by using mid-span supports. Plastic sheeting should not be used in applications where it approaches its deflection limits (50 mm).

*Shallow symmetrical profiles of plastic roof lighting can be curved to suit draped curved metal cladding. However, the radius is determined by the profile, material type and thickness. See 15.1 Curved Roofs*
*When long lengths of plastic sheeting are not supported at mid-span, their longevity is reduced and incremental failure can be caused by the flexing at their fixing points.*
The two main factors that limit spanning capability are deflection and pull-through over the fasteners.

As standard weight plastic roof lights have a low pull-over load and the critical condition is that imposed by wind suction; their performance is determined by the number of fasteners per square metre.

**Load-spreading washers specifically made to fit the plastic sheeting must be used under all fasteners.**
**All fixings and washers must meet the same durability standard as the roof and wall cladding.**

**All plastic sheeting must have an enlarged fixing hole for the provision of thermal movement, predrilled to the following diameters for 12# or 14# self-drilling screws for both timber and steel purlins.**

**The fixing must be positioned in the centre of the oversize hole to ensure that the sheet has equal movement in all directions around the fixing.**

### 14.8A GRP Fixing Positions

| | |
|---|---|
| For G.R.P. | |
| Sheets up to 6 m | 8mm |
| Sheets 6 to 9 m | 10mm |
| Sheets 9 to 18 m | 12mm |

## 14.8B PVC Fixing Positions

| | |
|---|---|
| For PVC and Polycarbonate | |
| Sheets up to 4 m | 10mm |
| Sheets up to 6 m | 12mm |
| Sheets over 6 m | NR |

*The minimum fixing pattern for roof lighting cladding is determined by the span, the design load and the profile thickness, but fixings with load-spreading washers are recommended for all profiled ribs, except for spans less than 1 m.*

**Tray profiled GRP roof sheeting must be mechanically fixed to provide for the uplift load specific to the site, and must be placed on top of the adjacent metal sheeting.**

In extreme environments where there are chemical fumes and the fixings are prone to chemical attack from the inside of a building, stainless steel fixings should be used.

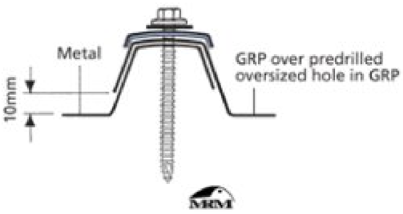
When pan fixing is used, the fastener should be positioned within 25 mm of the rib.

## 14.8.1
## Side-Lap Fixing

As there is no capillary bead formed on the side laps of plastic roof lighting, the fixing should be in the top and not the side of the rib. The overlap rib of the translucent sheeting should have a minimun clearance of 10 mm from the pan to avoid capillary action.

**The side-laps of GRP sheeting and of the adjacent sheet must be fixed through the top of the rib with oversize holes in the GRP and load spreading and sealing washers.** ***(see drawing 9.7.1.)***

## 14.8.1A GRP Fixing




## 14.8.2
## Side Lap Fixing Between Purlins

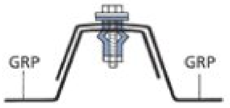
When side lap fixing GRP to metal, an oversize hole should be pre-drilled in the GRP and a coarse thread Type 17 screw used with a profile metal washer and EPDM seal.

## 14.8.2A GRP to Metal


**The side-lap fixing between purlins of GRP sheeting and the adjacent sheet must be fixed at maximum 600 mm centres through the top of the rib, with oversize holes in the GRP and load spreading and sealing washers.**

When fixing GRP to GRP, a rubber-nut or grommet can be used and installed from the top side of the roof sheet using a 35 mm long, 4.5 mm diameter, aluminium or stainless steel gutter bolt and a 20 mm diameter metal and EPDM sealing washer.

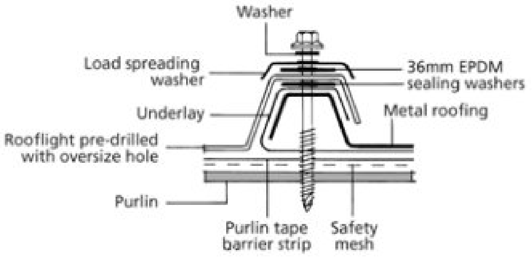
## 14.8.2B GRP to GRP




Alternatively, if Bulb-Tite rivets are used a clearance hole is required, and care should be exercised when setting the rivet to avoid stress at the connection. This fixing is not suitable for use in high design wind load areas.

**Underlay or foil must be terminated at the lap to provide continuity for any condensation that may occur.**

## 14.8.2C Underlay End — GRP




When fixing tray decking profiles and using matching roof lighting sheets, there are several fixing options depending on the configuration of the profile. The independence of the metal and plastic sheeting should be maintained with all profiles to allow for their differing rates of expansion.

## 14.8.3 End Laps

**The minimum end lap of GRP sheets with metal or GRP profile sheeting must be 200 mm. These laps must**

**be sealed, and the bottom end of the overlapped sheet must be within 50 mm of the lower side of the purlin or saddle flashing.**

**Two lines of sealing beads or compressible strips must be placed, one within 15 mm from the bottom of the top sheet and the other 15 mm from the top of the bottom sheet.**

**Only compatible sealants must be used with plastic sheeting.**

Silicone sealants should not be used with polycarbonate roof lighting.

The sealant materials for end laps of plastic sheeting should be neutral cure silicone, EPDM closed cell foam with self-adhesive on one face 25mm x 3 - 5mm thick, or polythene butyl tape.

## 14.8.4 Midspan Supports

**Unless the thickness of the plastic sheeting is increased to equal the performance of the metal sheeting, mid-span supports or span breakers with a minimum thickness of 0.95 mm coated steel must be used as a mid-span support for all purlin spacings over 1.2 m.**

**Mid-span supports must not be used for more than one plastic sheet next to each other. Where two or more adjacent sheets are used together, the purlin spacings must be reduced to the maximum allowable for the profile, the thickness of the sheet and the design load.**

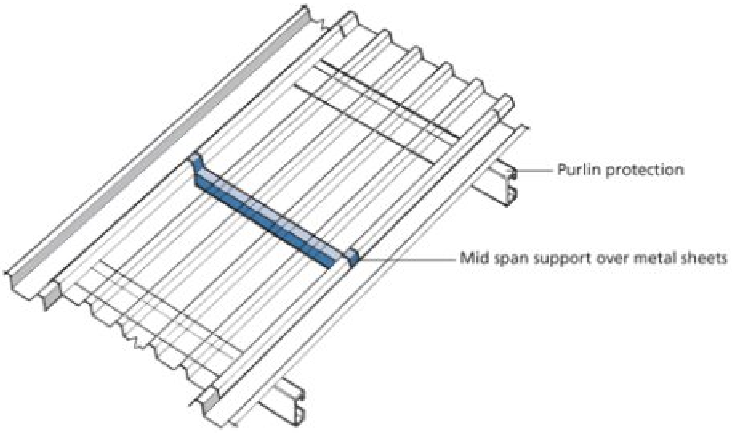
A mid-span support is used at mid-span at spacings, dependent on the profile, to gain additional support from the metal cladding for the plastic sheeting.

Single sheets of plastic roof sheeting placed between adjacent metal sheets can only have the same purlin spacings as the metal roofing profile when a mid-span support is used, or the plastic sheeting thickness has been increased to provide the same performance characteristics as the metal sheeting. The exception to this condition applies only when the plastic sheeting has been tested for point loads as described in 17.7 Wind and Point Load Testing.

The mid-span support member is not intended to support point loads from foot traffic and should be of sufficient strength and stiffness to prevent the plastic sheet deflection being greater than that of the adjacent metal sheeting.

Mid-span supports provide the uplift strength required to reduce sheet flutter in high winds. To prevent any movement between adjacent sheets they should be fixed with a type 17 screw and load spreading washer through the GRP and span breaker, and they should be fixed to the metal sheeting.

### 14.8.4A GRP with Mid-Span Supports




*Plastic roof light sheets over metal.*

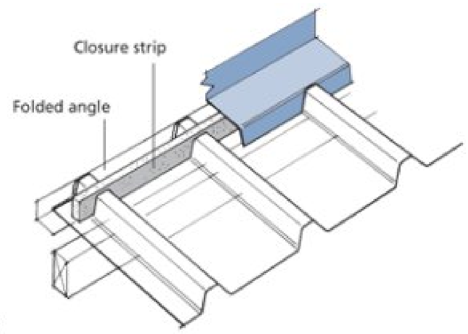
## 14.8.5 Stopends

*Stopends can be used to weatherproof the ends of sheets in two ways.*

1. *By the use of profiled closure strips fitted close to the screw fixings of the over flashing.*
2. *By the use of an angle made from a durable material equal to the adjacent metal sheeting and sealed to the sheeting.*

*If (1) is used in exposed areas, the profiled closure strip should be sealed to the plastic sheet ing to act as a wind barrier.*

### 14.8.5A GRP Stopends




## 14.8.6 Purlin Protection

Because of expansion movement, safety mesh will cause damage to the plastic sheeting at the purlin line, and it should be isolated at the purlin. This protection should be a foam tape or other durable and non-absorbent material and be of sufficient thickness and resilience to avoid damage. It should extend the full width of the purlin flange and should include both purlins where purlins are lapped .

**When plastic roof lighting is laid over safety mesh or wire netting, protection must be placed over the mesh or netting to avoid damage to the underside of the plastic roof lighting.**

## 14.8.7 Drainage

Acrylic or fibreglass domes should not rely on sealants alone for weathertightness. The design of the penetration flashings should allow for adequate water drainage.

**A water diverter-type penetration design must be used for penetrations wider than 600 mm, and proprietary rubber flashings must be placed at 45° to the roof pitch, as described in 9 External Moisture Penetrations.**

**Acrylic domes must not be used with unpainted galvanised flashings, and plastic roof lighting must not drain onto galvanised roof cladding or gutter.**

**To avoid inert catchment corrosion galvanised metals must not be used in conjunction with plastic roof lighting.**

## 14.8.8 Condensation

*In areas or buildings likely to suffer heavy condensation, the use of a second translucent sheet to form a double skin can be used to minimise condensation. See 11.3 Types Of Roof Lights.*
*Twin skin plastic sheeting should have a minimum gap of 20 mm and should be spaced with insulating material between the sheets at the fixing points. It is standard practice to place the second sheet above the first after it has been fixed; however, a special ridge is required as shown on Sprung Roof.*
The top sheet fasteners penetrate the structure deep enough to resist the negative wind load.

*Elevated roof lights, designed specifically for long run tray roofs from ridge to eaves, are fixed to the ribs of the sheet and permit condensation to run off onto the trough.*
*A UV stabilized grade of clear polythene film or sheeting can also be used in order to help control any condensation dripping from the plastic roof lighting, but its durability may be less than that of the plastic roof sheeting.*

## 14.8.9 Pitch

*The minimum pitch is the roof cladding pitch and not the building design roof pitch. The allowable cumulative deflections of the frame, purlin, and roof sheeting require the building design roof pitch to be increased to comply with minimum cladding pitch.*

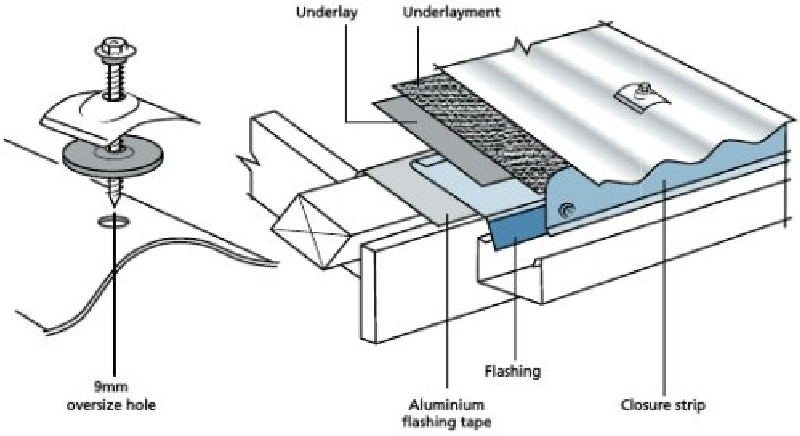
*Plastic roof lighting profiles deflect more than metal roof or wall claddings of the same dimension. See 3.5.3 Deflection.*

*The COP recommends that the roof pitch for plastic roof lighting profiles is increased to more than the minimum for the profile, in addition to that recommended for allowable deflections (1.5°).*

*It is better practice that all plastic roof lighting profiles with sheets longer than 15 m should be a high rib profile (more than 35 mm) or that the roof pitch should be increased by 3° over that required in 7.1.1 Minimum Roof Cladding Pitch.*

# 14.9 Fixing Aluminium Sheeting

## 14.9A Aluminium Sheeting with Underlay




**Because aluminium roof and wall cladding are often used in severe and very severe marine environments, direct contact with an absorbent permeable underlay must be avoided in areas subject to salt spray ingress.**

*Corrosion at the interface of the cladding and the underlay is likely to cause pitting where marine salts can gain access to the roof cavity and the time of wetness (TOW) is high. This restriction applies at all exposed ends of the sheets, such as at spouting, gutters, and valleys; in most cases, it extends to the penultimate purlin. In these places underlay as described in 10.7.5 Non-Residential Buildings is recommended as the separating medium between the aluminium sheeting and the purlin.*

**Wire netting (including plastic coated wire netting) must never be used as an underlay support without separation to the netting.**

**Self-supporting permeable underlay should be fixed at the roof underlap with stainless steel staples, avoiding contact with the aluminium, and should not extend more than 20 mm into the gutter to avoid wicking.**

*If the pitch is less than 8°, it is recommended to use a self-supporting synthetic underlay laid horizontally and stretched tight between the purlins at less than 1100 mm with durable synthetic string or strapping attached to the face of the purlins.*

*Note: As corrugate is not laid at a pitch of less than 8°, self-supporting underlay can always be used for this profile, without any additional support.*

**Aluminium sheeting, flashings and cappings must not be fixed directly to butyl membrane gutters or roofs for the same reasons as given above, but must have ventilation and underlay as described. Impermeable separators such as DPC can also retain moisture and ultimately cause underside corrosion.**

*As required with other profiled metal roof cladding, ventilation is necessary to avoid moisture build-up in the cavity, particularly where skillion roofs or cut-in purlins are used. A minimum gap of 20 mm is required between* *the underlay and insulation, and if necessary deeper purlins or a counter batten should be used to get this clearance. See 14.6 Installation*

*Fasteners for fixing aluminium sheeting can be either aluminium, which are suitable for timber construction, or Grade 304 stainless steel. However, to obtain maximum durability, both are required to have a 10 mm oversized hole to avoid bimetallic contact and expansion noise.*

*Load spreading profiled washers are required when oversized holes are used, and these should be made from aluminium or grade 445M2 stainless steel used in conjunction with an EPDM 36 mm isolation washer. Aluminium embossed washers can also be used on some profiles and flashings.*

*When fixing aluminium corrugate or trapezoidal cladding, an aluminium gutter apron flashing is recommended to be used. See 8.4.4.4 Eaves Flashing.*

**To comply with this COP an apron flashing is required where the pitch is less than 10° and the site exposed.**

*A secret fix roof cladding system minimises the entry of salt-laden air, but when using a corrugated profile, an eave profile closure as discussed in 8.7.1 Soft Edging should be used. The use of high fronted spouting profiles is also recommended to help minimise entry of salt-laden air into the roof cavity.*

## 14.10 Metal Roof Defects

The following guidelines apply to residential cladding. Cosmetic issues are very subjective according to the degree of visibility and the nature of the job, and this should be taken into consideration when assessing compliance.

**Scratches**

Due to the self-healing qualities of metallic coated profiled roofing and factory applied organic coatings, minor scratches will not affect durability as long as they do not extend to the base metal. Generally, isolated scratches that are not readily visible from a distance of 3 m are deemed acceptable.

**Swarf**

Visible swarf resulting from the use of incorrect cutting practices, or grinders, is a defect. Light swarf and rust spots arising from recommended cutting and drilling practices should be removed, but harsh abrasion is not recommended, and some light residual staining is not a defect.

**Paint Fade and Colour Differentiation**

Excessive paint fade from factory finish, or differential fade from different paint systems or suppliers, is not acceptable and is a defect.

Accessories colour matched before installation may fade at a different rate to the cladding, and this is not a defect.

Colour matched paint may be used to pre colour match certain accessories before installation. If used to repair scratch damage to roof or wall cladding it is a defect.

**Fastener Pattern**

Fasteners should be installed in a regular pattern following the Code of Practice or manufacturer's literature. Fasteners should be applied to all support members crossed by the cladding, failure to do so is a defect unless specifically allowed by the designer or engineer.

**Fastener Alignment**

The degree of fastener alignment that is acceptable varies with the visibility and line of sight of the roof. Fasteners on wall cladding, or on highly visible roof sections, not aligned within 10 mm is a defect.

**Fastener squareness**

Fasteners not driven square to the profile within 5° of vertical is a defect.

**Uneven Notching**

Notching of flashings over ribs that is not symmetrical and consistent, with gaps greater than 5 mm is a defect.

**Oil Canning**

Oil canning is common with standing seam products and can occur with other wide pan profiles from time to time. This will become less apparent with weathering and is not a defect with those profiles.

### Lichen

Lichen build up is a natural; occurrence and not a defect. However, its presence will affect the durability of the roof and it should be removed as recommended by the manufacturer.

### Clip Creasing

For strength of engagement, a secret fix clip into trough section is normally required to have an interference fit, which may show through the narrow throat of the rib. This is will become less apparent with weathering and is not a defect provided deflection is less than 3 mm.

### Sunscreen Damage

Improper formulations of sunscreen may affect the paint coating on contact. This is a defect and these sheets should be replaced.

### Thermal Noise

Some roof noise must be expected, particularly when translucent sheet is used and is not a defect. Flashings should be designed to minimise thermal and wind noise. Environmental noise is not a defect.

### Incompatible materials

Runoff from copper onto painted and unpainted metallic coated profiled metal is unacceptable and is a defect. Contact with copper, lead, stainless steel, cedar, wet concrete wet butyl rubber soil, fertiliser, and certain other materials is a defect. See 4.10 Compatibility.

### Leaks

Leaks are unacceptable, and they are a defect.

### Staining

Staining caused by runoff from materials that are incompatible with the roof material is a defect. Examples are copper, concrete splashing, harsh chemicals, and solvents. Solutions range from cleaning to sheet replacement

### Condensation

Excessive or persistent condensation and should be discussed with the main contractor or designer. Condensation caused by the drying of wet timber or concrete is not a defect and should be managed by the contractor to minimise the effect.

### Squareness of lay

The degree of squareness that does not constitute a defect depends on the application and exposure of the cladding, and the squareness of the structure on which the cladding is being laid. Generally, variation of up to 20 mm in 10 m is not a defect for roofing. Wall cladding should generally be square to within 10 mm in 10 m or 5 mm per 10 m in highly visible situations.

### Exposed Sealant

Exposed sealant will attract dust and is a cosmetic defect. If it is in evidence of the sealant being applied on top of the joint rather than sandwiched between the two surfaces, it is a defect.

### Strippable Film

Strippable film left exposed to sunlight too long and that cannot be removed without damaging the sheet is a defect.

### Rib Dents

Isolated rib dents will become a weatherproofing defect and can be repaired with a rib cap riveted over the affected area. Repaired isolated dents are not necessarily a defect. Sheets having two dents within a purlin space are a structural defect and should be replaced.

### Ponding

Complete blockage of the pan by the installation of penetrations is a defect. Flat back flashings that hold more than 3 mm depth of water, or sheet pans that do not drain freely due to insufficient fall or structural damage is a defect.

### Back Flashings

Back flashings greater than 1 m in width should be avoided by design and are a defect.

### Contamination

See staining, above.

### Glare

Glare will reduce with time and is not a defect.

### Overhang into gutter

Overhang into the gutter of less than 30 mm is a defect. When the roof sheet ends are not protected by thefront of the spouting, and an eaves flashing is not installed, an overhang of less than 45 mm is a defect.

### Bird Entry

Details that allow birds to enter the roof cavity are a defect

### Purlin Creasing

Minor creasing when using wide pan trapezoidal profiles, particularly in 0.40mm steel and 0.70mm aluminium is not a defect and can be expected. Major creasing due to purlin misalignment, overtightening of screws or traffic is a defect.

### Side Lap Visibility

The side lap of cladding may be uniformly visible from certain angles which is a result of anti-capillary design, and this is not a defect.

### Concertina Effect

Crushing of flashings due to shrinkage of timber to which it is attached is a defect.

### Spouting, Fascia/Gutter

Strippable film left on fascia gutter is a defect. Film residue should be removed. Joints should be neat and fastenings colour matched and aligned with no visible silicone.

Brackets must fit correctly; bracket marks and rattling are defects. Gutters should fall towards an outlet, ponding of up to 5 mm is not a defect. Internal gutters must be provided with an adequate overflow. Downpipes should be aligned parallel with the most adjacent vertical element.

# 15 Other Products

Other roofing products, include:

- Curved Roofs.
- Solar Units.
- Pressed Metal Tiles.
- Standing Seam Cladding.

## 15.1 Curved Roofs

*There are two main methods to clad curved buildings.*

1. *Draped sheets, known as spring curving.*
2. *Pre-curved sheets, either roll-curved or crimp curved.*

For compliance with the requirements of the NZBC, designers should abide by the limitations of profiled metal cladding for curved roofs.

The curving process or crimping does not produce any strength enhancement for point or wind load. Curved roofs usually have maximum purlin spacings to avoid distortion.

Designers and contractors should be aware that light gauges such as 0.40 mm steel and 0.70 mm aluminium are likely to show distortion when used for curving.When asymmetrical-pan trapezoidal cladding is used for curved roofs and appearance is paramount, a heavier gauge cladding should be specified.

They are 'Restricted Access' roofs, which means that walking traffic should be restricted to within 300 mm of the purlins, and in the pan or over two ribs if they are adjacent to the vertical lap. Because of the changing pitch, edge protection must be provided, or a safety harness used when installing curved roofs. See 13.1 Safety.

**All side laps of curved sheets below the minimum pitch for the profile must be mechanically fastened and sealed.**

*Curved flashings are described in 8.4.5 Curved Flashings*

### 15.1.1 Spring Curving

*Spring curving, also known as draping or arching of roofs, is a method of providing continuous lengths of roof cladding over a curved roof structure from eave to eave without a ridging. It is suited to symmetrical roofing profiles of low rib height, which can follow a curve without excessive panning or distortion.*
*Because these profiles do not have a large rain- water carrying capacity they are limited in radius and length.*

Maximum radius is limited to provide adequate drainage at the top of the curvature and minimum radius is limited to avoid distortion without pre-forming.

Asymmetrical and tray roof cladding can be draped , but only to a large radius before panning or distortion occurs and they are , therefore , unsuitable for all except large radii. They do not have the same restrictions on rain- water carrying capacity as symmetrical claddings. Because corrugate cannot be satisfactorily turned down into a gutter, wind pressure can drive rain up the corrugations, causing 'blow back' and allowing water ingress. Spring curved corrugate should not terminate below 8°.

**Roof cladding must not terminate at a lower pitch than that permitted for the profile , unless the designer can demonstrate compliance with the NZBC by detailing an alternative method of weathering and**

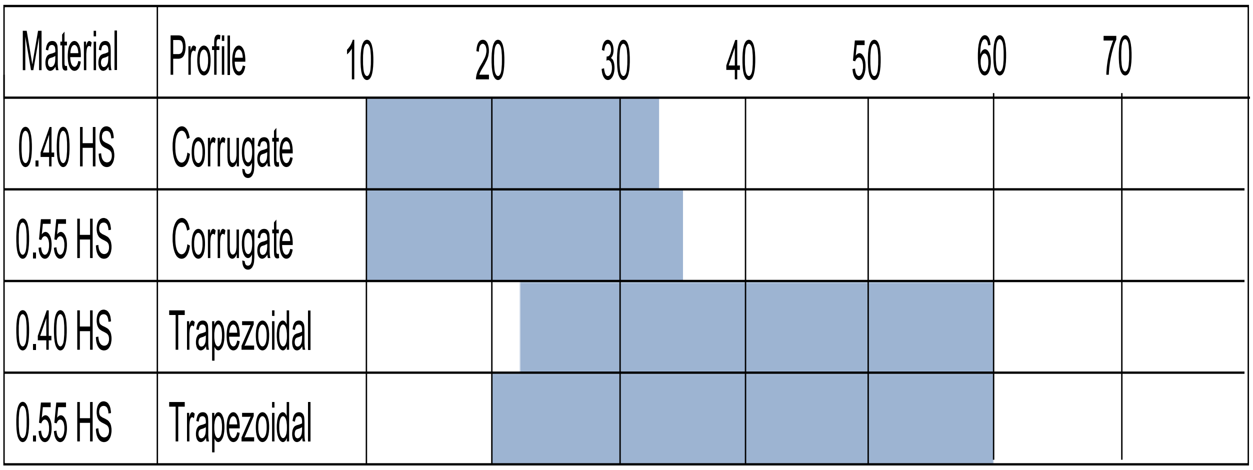
durability.

All trapezoidal and tray roof cladding below 8° must have the pan turned down into the gutter.

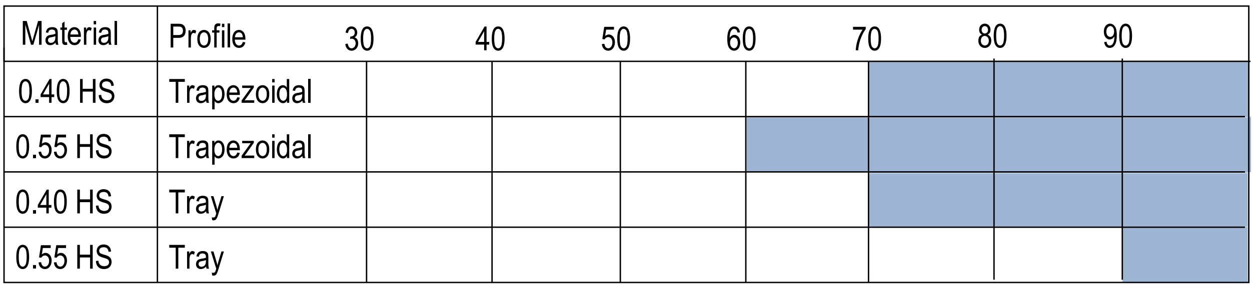
All roof cladding at all pitches must have either a pull-up or a dog-eared stopend.

*If the width and height of the roof are known, this information can be used to obtain the radius of curvature and subsequently the sheet length and the length of seal required for any profile.*

## 15.1.1A Recommended Radius for Concave and Convex Curves in Symmetrical Profiles




## 15.1.1B Recommended Radius for Convex and Concave Curves in Asymmetrical Profiles

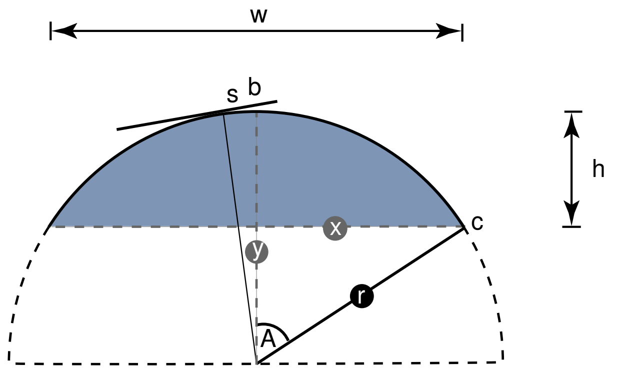



Only G550 MPa grade (HS) coated steel is recommended for drape curving.

*Tables 4.9.1.A & B assume the cladding is draped over an arc where the base chord is parallel to the ground. When the base chord is on an incline the maximum radius can be increased.*

*If the width and height of the roof are known, this information can be used to obtain the radius of curvature and subsequently the sheet length and the length of seal required for any profile.*

## 15.1.1C Spring Curving Calculator




**Definitions**

| | |
|---|---|
| Width | = w |
| Height | = h |
| Radius of curvature | = r |
| Minimum pitch | = p |
| Sheet length | = l |
| Length of seal | = s |

The Code of Practice Online provides an interactive tool for these calculations. This tool is only available online at 15.1.1C Spring Curving Calculator

### *Full Calculation Details and Example*

| ***Formula*** | ***Example*** | |
|---|---|---|
| *Start with : **w** = Width of roof* | | |
| $w$ | = 12 | |
| *Start with : **h** = Height of roof* | | |
| $h$ | = 5 | |
| *To find **r** the radius of curvature* | | |
| $r = \frac{4h^2 + w^2}{8h}$ | $= \frac{(4 \times 25) + 400)}{40}$ | = 12.5 |
| *To find **l** the sheet length* | | |

| | | |
|---|---|---|
| *Find the length* **y** | | |
| $y = r - h$ | $= 12.5 - 5$ | $= 12.5$ |
| *Find the length* **x** | | |
| $x = \frac{w}{2}$ | $= \frac{20}{2}$ | $= 10$ |
| *To find the tangent of angle* **A** | | |
| $\tan A = \frac{x}{y}$ | $= \frac{10}{7.5}$ | $= 1.33$ |
| *To find angle* **A** | | |
| $A = aTan(\frac{x}{y})$ | $= aTan(1.33)$ | $= 53°$ |
| *Find the arc length* **c b** | | |
| $c\,b = \frac{2\,\pi\,r\,A°}{360}$ | $= \frac{2 \times 3.1412 \times 12.5 \times 53}{360}$ | $= 11.56$ |
| *Find the sheet length* **l** | | |
| $l = cb \times 2$ | $= cb\ 23.12 + 100mm$ | $= 23.12$ |
| *To find the length of seal*<br>*p = Min Pitch for corrugate = 8°* | | |
| $s = r \times (\tan 8°)$ | $= 12.5 \times 0.1405$ | $= 1.76$ |

N.B. This length of seal is required on each side of the crest.
It is recommended that all profiles be sealed to 8°.

If the sheets are lapped laterally they must be sealed.

## 15.1.2 Laps

By definition, a curved roof is flat at the crest of a curve, and because it is below the specified minimum roof pitch required by the NZBC for unsealed laps, side laps should be sealed over the crest of the arch until the minimum pitch is reached.

All vertical laps should be sealed if the pitch is less than the allowable minimum as tabulated below:

## 15.1.2A Curved Roof: Sealed Lap Pitch

**Minimum pitch below which vertical laps should be sealed**

| Profile | Pitch |
|---|---|
| Corrugate | 8° |
| Symmetrical Low Trapezoidal | 4° |
| Asymmetrical Low Trapezoidal | 3° |
| Secret-fix Tray | 3° |

*When the pitch of the roof is below the minimum, the side lap is required to be sealed over the crown, and lap tape or silicone sealant should be placed on top of the rib and firmly held down while fixing takes place. Intermediate side stitching is required at the midpoint of all side laps using self-sealing rivets or stitching screws.*
*The side lap of profiled sheeting is designed with anti-capillary provisions to be self-draining.*
*Before the continuous manufacture of corrugate from coil, symmetrical corrugate sheets were often laid with two nesting laps, which commonly corroded due to condensation, even when the laps were primed. All metal profiles now produced in NZ have capillary grooves. Trapezoidal profiles are designed for one lap only and corrugate used for roofing is designed for 11/2 laps with an under and an over.*
*Avoid double lapping because condensation can become trapped in the lap, which can cause accelerated corrosion with all steel products, including pre-coated steel. Lap priming should not be used as the permeable paint surface can retain moisture and accelerate corrosion.*

## 15.1.3 Transverse Laps

To avoid a transverse lap, or if the sheet is longer than can be transported or safely handled, a step in the roof structure should be provided. See 8.4.4.3 Step Apron.

**At a step or a lap, the end span must be reduced. See 3.5.1 Point Load.**

**If a transverse lap cannot be avoided, it must be mechanically fastened and sealed and must be made watertight from the inside by lap tape or sealant.**

The sealant should ensure that the condensation flows past the joint and either be absorbed by the underlay or drain to the eave.

*Severe corrosion problems have been caused on curved roofs by condensation running down the inside of roof cladding and into the laps. This was a common mode of failure when short lengths of galvanized corrugated sheeting were used in the past, but long run roofing without end laps has significantly reduced this type of failure.*
*Do not assume that the paint coating would provide barrier protection. The manufacturers' and industry requirement, since 1995, is to seal all transverse laps.*
*The time of wetness, which is a major factor of corrosion, is increased when unsealed metallic coated steel cladding and flashing laps are subjected to a continuously damp environment. This situation is also detrimental to pre-painted metal cladding, which are attacked through the permeable paint coatings and at cut edges.*
Where a draped roof is regarded as too long to transport or too difficult to handle as a drape curve in one sheet, the crown sheet should be as long as practical and the transverse lap should be placed as far down the roof as possible to increase the pitch at this point.

At the termination of curved sheets at minimum pitches in exposed areas, additional weathering is required at the turn down. Ventilated filler blocks and/or baffles should be used to prevent blowback, which can cause corrosion because the underside of the sheeting becomes an unwashed area.

**Penetrations or end laps must not be placed in the region of the curve where the roof pitch is below the minimum pitch for the profile in 7.1.1A Minimum Recommended Pitch.**

**Additional timber or steel supporting structure must be installed upside and downside of any penetration hole greater than 300 mm x 300 mm to provide fixing for the sheet and a reduction of the end spans.**

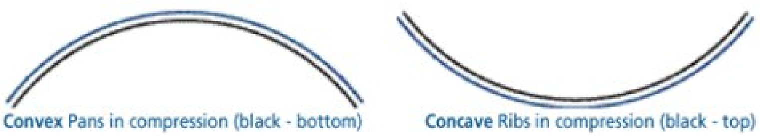
**Support must be provided to resist the uplift on sprung curved sheets at all penetrations.**

**All side laps of curved sheets below the minimum pitch for the profile must be mechanically fastened and sealed.**

Continuity over a minimum of three purlins is required for successful drape curving and therefore any interruption, such as a penetration or other cutting of the sheet, may require machine curving to ensure the curvature is maintained.

*Purlins must be accurately positioned with the top faces tangential to the radius of the arch and should be within a 5 mm tolerance to avoid purlin creasing. Roof traffic should be restricted to avoid damage, particularly in the low pitch region or in highly visible areas. Damage as a result of walking traffic can be seen as creasing at purlin lines or canning in the profile pans.*
*Some purlin creasing is to be expected with stronger profiles, and at low pitches this can cause corrosion due to ponding. For convex roofs, the minimum radii should be adhered to because the pans are in compression, whereas with concave roofs the pans are in tension and the panning or distortion of these roofs will be less , although it depends on the profile.*

## 15.1.3A Concave and Convex Compression




*Only vented profiled filler blocks should be used at the eave on curved roofs so that some air movement is provided within the ribs. See 10.6 Ventilation.*
*Provision for expansion should be provided in the same manner as required for straight lengths, but the configuration of curved roofs means that some expansion will be taken up by a springing of the profile further up, which results in less movement. When the total sheet length is considered for expansion, positive fixing using oversize holes, should be made at the crown.*

## 15.1.4 Durability

When draped curve roofs are unlined and used as canopies or exposed eaves, the underside of the sheeting becomes an unwashed area. Therefore, it needs to be washed and regularly maintained to comply with the durability requirements of the NZBC and the supplier's warranty. The underside of pre-coated roof cladding is provided with a primer and backer coat only; it is not as weatherproof or UV resistant as the top-coat.

Because pre-painted cladding is not intended for use in this micro-climate without regular maintenance, the underside of the soffit should be lined in all severe and very severe environments.
(see *16 Maintenance* )

## 15.1.5 Purlin Spacing

When the purlin spacing is close to the maximum allowable for the profile and ease of curvature, the roof cladding is more likely to be damaged by foot traffic and distortion between the purlins. When the radius of curvature is close to the minimum, the purlin spacing should be reduced to the end span distance for each gauge and profile. See 3.16.5 Wind Load Span Graphs.

Access on curved roofs should be restricted and be regarded as Type B, and extra care should be taken during installation because of the changing pitch. Because some profiles used for curved roofs are close ribbed, it is not possible to walk in the pan. The walking pattern should be restricted to within 300 mm of the purlin and the load spread over two ribs. This is more important when low strength steel is used for pre-curved sheets.

Avoid using 0.4 mm G300 steel or 0.7 mm aluminium for roof cladding subjected to walking traffic.

The designer should consider the radius of curvature, profile, thickness, grade, and purlin spacing as these are all related parameters of curved roof design.

Maximum purlin spacings should be adhered to and any sheets damaged by foot traffic in the area below the minimum pitch for the profile should be replaced.

All curved roofs must have end spans reduced to two-thirds of the intermediate span, as required for straight roofs because the kl load - factor requires a reduction in purlin spacing at the roof edges. Where translucent sheets are required to be curved, the normal purlin spacings should also be reduced.

If the design loads are high, or where the eave is not lined and the roof cladding is exposed, extra fixings and load spreading washers are required.

It is important that the radii limitations and water drainage characteristics for specific products are considered at the building design stage so that water runoff over the low pitch region will not exceed the maximum for the profile used. The maximum radius of curvature permissible for corrugate and symmetrical profiles is limited for this reason.

Bull-nosed verandah or lean-to roofs, which are simply supported spans and do not have the continuity required for point load, should have their purlin spacings reduced to less than normal end spans.

Because the sheeting is continuous over the top of a curved roof and the wind dynamics are different, purlin spacings do not need to be reduced at the crest, as is normally required at the ridge on gable or hipped roofs.

The two top purlins should be placed to enable the sheeting to follow an arc that minimises purlin marking.

*Draped curved roof or curved ridges should be fixed by fastening each sheet first to one side of the roof and then pull* *it down to be fixed on the other side. Alternate sheets should be laid in sequence to avoid cumulative errors and be laid from opposite sides of the roof to ensure squareness is maintained. Shift the two top ridge purlins to provide an even radius.*

### 15.1.5A Laying Draped or Curved Cladding

Because extra uplift load will be taken by the end fasteners, screws and load spreading washers should be used on the penultimate and the last purlins and screws are the preferred fastener for curved roofs, although nails may be used on intermediate purlins.

**Rafters and purlins must have additional fixing to the structure to resist the additional uplift load at the eave caused by curved sheeting.**

*Any assumed increase in span due to an increase in strength of the roof curve should be discounted, as concave and convex draped curved roofs are limited to the maximum purlin spacing allowable for the particular profile, and are dependent on the wind design load.*

## 15.1.6 Concave Roofs

Roofing can be spring-curved into concave shapes however designers should be aware of the limitations on the minimum pitch where the curve is terminated, the extra uplift load that will be taken by the fasteners at the centre of the curve, and take into account the catchment area of the roof.

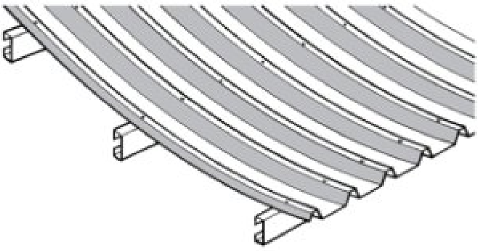
The pitch for concave roofs must not be less than 8° for corrugated profiles, 4° for symmetrical trapezoidal profiles, and 3° for other profiles. Screws and load spreading washers must be used for fixing cladding on all sprung concave curved roofs. The purlins must have additional fixing to the structure to resist the extra uplift load on sprung curved sheets.

*The additional load produced by draping concave and convex metal roof cladding depends on the radius of curvature and the thickness of the metal. The induced load has two forces:*

- *additional load on the fastener; and*
- *additional load on the purlin/rafter or truss connection.*

*Although the former is the responsibility of the roofer, the COP recommends that the purlin connection is inspected for adequacy. The connection prior to any additional load imposed by the draped roof will be determined by table 3.6. An economical solution to the increased connection load is to use a proprietary purlin strap.*

### 15.1.6A Concave Roofs

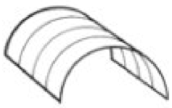


## 15.1.7
## Pre-Curved Roofs

Low tensile metals and G 300 coated steel can be easily roll-curved in a pyramid rolling machine to small radii and can also be crimp curved into these shapes. See 15.1.9 Crimp Curving.

### 15.1.7A Bullnose

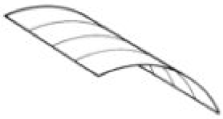
### 15.1.7B Barrel Vault



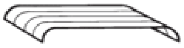
### 15.1.7C Ridge

### 15.1.7D Cranked Double Curve

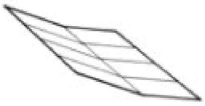
### 15.1.7E Convex



### 15.1.7F Double Curve



### 15.1.7G Reverse Curve



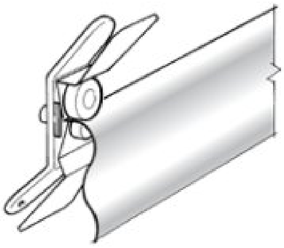
## 15.1.8 Roll Curving

*Pre-curved corrugated roof cladding is used for bull-nosed verandah roofs, ridges, or for roofs where the radius is less than the minimum required for sprung or draped curved roofs.*
*Corrugated (symmetrical sinusoidal) G300 roof cladding is easily curved or bull-nosed. The sheets are passed through matching curving rolls, which progressively form curves in a wide range of radii. If G300 and G550 steel sheets are to be used together, because these two materials will not have matching profiles, adjustment of the roll-forming machine setting is necessary.*

Circular barns have been successfully cladded with 0.4 mm steel for many years, but 0.55 mm steel or 0.9 mm aluminium should be used for roll-curved roofs subject to foot traffic. G300 coated steel of 0.4 mm and 0.7 mm aluminium are only suitable for roofs without access or for wall cladding.

*G300 steel can be curved to a radius as small as 300 mm using pyramid curving rolls. There is, however, a straight portion of about 80 mm at the end of the sheet which may need to be trimmed off if a true curve is required.*
*If the edge of the sheet is too flat or long, rippled edges may result, and these should be dressed out using a dressing tool or trimmed off before the sheet is installed.*

### 15.1.8A Dressing Tool



*A curve can be rolled on one end of a straight length of roof cladding to provide an over or cranked ridge, but for ease of fitting and transport, a lap is usually made at the first purlin down from the ridge. This should be sealed in the same manner as is required for any transverse lap.*
*An alternative ridge detail can be used with straight sheets, without any lap, by roll curving or draping the cladding over the ridge, where the ridge purlins are extended their maximum span.*
*For safety, roofs which are often used as a means of access to or onto a verandah should be provided with an intermediate support. Simply supported roofs cannot withstand foot traffic to the same degree as continuously supported sheeting.*

## 15.1.9 Crimp Curving

Crimp curving is applicable to all profiles, but it is most suited to asymmetrical sections that cannot be rolled or drape curved.

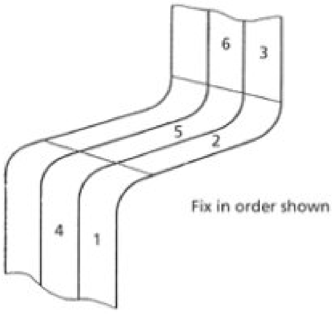
Crimp curving is produced by pressing a small crimp in either the tops of the ribs or the pans of the sheeting. The profile is progressively shortened at these points causing it to bend. The radius can be altered by the spacing of and the number of crimps.

Some machines are capable of forming high-strength steel by a combination of compression and tension in the die design, and some machines require the use of strippable film as a lubricant to avoid coating damage. Where sheets are to be end lapped and different strength materials are used together, machine adjustment is required to ensure an acceptable fit because their profiles are not usually consistent.

Fitting curved sheeting requires considerable care to ensure a satisfactory and aesthetically pleasing job. Setting out requires first checking that the materials delivered on site are within specified tolerances, and before commencing work the building should be checked for squareness.

The curving process can cause dimensional changes, which can lead to misalignment, so the sheets should be kept square with the building. Some minor saw-toothing at the gutter end is to be expected when fitting curved sheeting. When multiple curves are required that cannot be provided on one sheet, the sheets should be fixed in the order shown in 15.1.9A Fixing Order: Curved Sheets.

### 15.1.9A Fixing Order: Curved Sheets




All transverse laps of crimped curved roof cladding must be mechanically fixed and sealed.

Some paint checking and microcracking is likely to occur at the crimps on metallic coated steel cladding and these may show a white bloom. This is more readily seen in unwashed areas, such as when crimp curved sheets are unlined as a canopy or over a walkway roof. This area is required to be washed regularly under the maintenance provisions of the supplier's warranty.

The underside of colour coated roof cladding is provided with a primer and backer coat only and if this is exposed in an unwashed area and can be seen, it should be post-painted with two coats of Acrylic paint. These areas are subject to maintenance as an unwashed area. (see over-painting section 13.7) Because the top of crimped sheeting is also subject to the collection of dirt and debris, particularly at the low pitched area, it is subject to maintenance requirements.

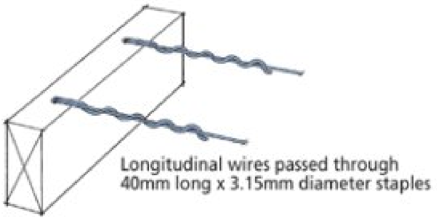
All side laps of crimped curved sheets below the minimum pitch for the profile must be mechanically fixed and sealed.

## 15.1.10 Timber Fixing

When attached to timber purlins, the longitudinal wires of the safety mesh must be either bent down and fixed to the sides of the purlins or fixed to the tops of the rafters by 40 mm galvanised steel staples with a 3.15 mm diameter and spaced at 150 mm.

Staples must be driven so that a cross-wire is between the end of the wire and the staple, or the end of the wire is bent back and twisted four times around the same wire so that individual wires cannot be drawn from a staple.

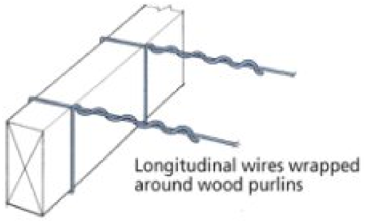
## 15.1.10A Longitudinal Wires Passed Through Staples




The longitudinal wires must be fixed to the purlins or rafters by galvanized steel wire loops of not less than 3.15 mm diameter. Place the centre of the tying wire around the longitudinal wire at an intersection, so that a transverse wire is between that point and the end of the longitudinal wire.

The tying wire must be passed once completely around the rafter, and then drawing the two tails of the tying wire in opposite directions over the two strands of the tying wire and twisting together with at least three complete turns.

## 15.1.10B Longitudinal Wires Wrapped Around Purlins




When joining rolls or sections, the two transverse wires must be placed together and the longitudinal tail wires must be twisted around each other. One longitudinal tail wire must be twisted four times around the main portion of the same wire. The other longitudinal tail wire must be twisted once around the main portion of the same wire and then four times around the two transverse wires

# 15.2 Solar Units

*Plastic roof lights are used in conjunction with profiled metal cladding in many industrial and commercial buildings to create an acceptable level of natural light in the working environment.*

# 15.3 Pressed Metal Tiles

## 15.3.1 Design

*Metal tiles, shingles and shake panels are press formed to provide a variety of shapes resembling clay tiles, wooden shingles or shakes. They are interlocked or overlapped laterally and longitudinally and are clipped or fastened to timber or steel battens.*
*Metal tiles, shingles and shakes are metallic coated steel are manufactured from metallic coated steel, although aluminium or other metals can also be used.*
*Pressed metal tiles made from steel invariably have an additional protective coating applied over the metallic coated steel. This may be an organic paint coating applied by either the steel manufacturer before the tiles are formed or by the tile manufacturer after the tiles are formed. An alternative coating can be provided by applying crushed stone or ceramic granules to the base metallic coated steel and attached by an adhesive coating; normally, a clear acrylic coat is used.*
*These coatings give protection to the metallic coated steel base, as well as providing a decorative finish.*
*Pressed metal roofing tiles are installed by fixers, trained and appointed by the manufacturers or their representatives, and they are not normally supplied to other installers.*

### 15.3.1.1 Durability

The principles behind detailed requirements for fixings, flashings, corrosion, compatibility, and maintenance as described elsewhere in this COP should also be applied to the design and installation of pressed metal tiles.

Exceptions result from the specific differences between tiles and other forms of metal roof cladding, and include the height of laps and specific dimensions of metal shingles and shakes prescribed in this section.

**Steel based metal tiles, shakes, and shingles must have hot-dipped galvanised fasteners that are compatible with the base metal and provide a service life equivalent to the durability of the panel.**

*Panels are fastened to the roof structure by fixing horizontally through the front of the panel; and because the fixings are in shear, they provide wind uplift resistance suitable for very high wind design loads.*

### 15.3.1.2 Pitch

Tiles with a minimum upstand of 25 mm must not be laid on roof structures less than 12° unless approved in writing by the tile manufacturer, the B.C.A. or the Territorial Authority.

Tiles, shakes or shingles with an upstand of less than 25 mm must not be laid on roof structures less than 15°.

N.B. The pitch of the roof is not the same as the pitch of the tiles because this varies with the height of the batten and the height of the upstand. If the minimum pitch cannot be complied with, a method approved in writing or a producer statement should be given before work is commenced.

## 15.3.1.3 Underlays

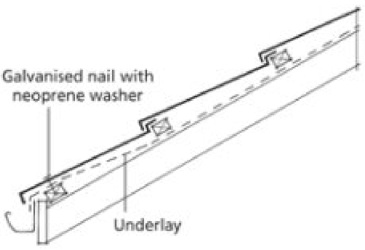
**Permeable self-supporting underlay must be installed on all new roofs as specified in section 4.3. of this Code of Practice.**

**The underlay must be installed horizontally with a minimum overlap of 75mm.**

The first length of underlay should be positioned so that it lays over the eave batten and the fascia, and into the gutter.

When pressed metal tiles are installed, the underlay is laid horizontally on top of the rafters before the battens are fixed, and so there is an air space between the underlay and the tiles, except at the eave.

### 15.3.1.3A Metal Tile Underlay




## 15.3.1.4 Roof Framing

Roof framing should provide support and fixing for the tile battens that will satisfy the design load wind requirements. Installers should check that the framing has been erected to an accurate and even line before roof fixing is started.

**An inspection and any rectification to the framing alignment must be carried out before roof fixing is commenced.**

## 15.3.1.5 Tiling Battens

**Tiling battens must be:**

- **H1.1 boric treated when used in attic roof construction;**
- **H1.2 treated when used in skillion roof construction;**

- **Douglas fir with a moisture content of less than 20%;**
- **KD Pinus Radiata with a moisture content of less than 18%;**
- **a minimum of 50 mm x 40 mm for 900 mm rafter spacing; and**
- **a minimum of 50 mm x 50 mm for 1200 mm spacing.**

**Copper preservative timbers must not be used with Zincalume coated tiles. Battens required for rafter spacings greater than 1200 mm must be specifically designed and be spaced to suit the tile module.**

**Battens at 370 mm centres must be fixed to the rafters or trusses over the underlay using fasteners to comply with Tables 10.1.5.A, B and**

N.B. Battens at different centres may require different values.

## 15.3.1.5A Batten Installation

- **Battens must have square cut ends and must be butt jointed over the centre line of the rafter.**
- **Adjacent rows of battens must not be joined on the same rafter and must span at least three rafter spacings at the roof edge.**
- **A batten must be installed immediately behind the fascia as fixing for the eaves tiles.**
- **Eaves tiles must overhang the gutter by a minimum of 30 mm.**

Eaves tiles are recommended to overhang the gutter by 40 mm.

Because an eaves-tile batten is installed immediately behind the fascia the position of the next batten up the rafter will be less than that of the normal tile batten spacing. The position of this batten may vary depending on the pitch of the roof.

The edge of the roof should be taken as 20% of the roof width measured from the fascia, barge, hip or ridgeline, and will apply all around the periphery of each roof plane.

The batten layout is marked on the rafters by placing nails at the line of the batten fronts. The roofing underlay is laid over this, onto the rafters. The battens are then laid from the lowest part of the roof upwards, using the marker nails to locate the front edge of the batten. The marker nails are removed before the tiles are laid.

## 15.3.1.5.1
## Pullout resistance for different constructions

## 15.3.1.5.1A Pullout resistance in kN required for battens for buildings with ceilings

cpe = -0.9, cpi = 0, cp = 0.9

| Purlin/ batten size | Max span | Wind Zone 0.61kPa | Wind Zone 0.61kPa | Wind Zone 0.82kPa | Wind Zone 0.82kPa | Wind Zone 1.16kPa | Wind Zone 1.16kPa | Wind Zone 1.50kPa | Wind Zone 1.50kPa |
|---|---|---|---|---|---|---|---|---|---|
| **mm x mm** | **mm** | **Low 32m/s** | **Low 32m/s** | **Medium 37m/s** | **Medium 37m/s** | **high 44m/s** | **high 44m/s** | **Very high 50m/s** | **Very high 50m/s** |
| | | M | P | M | P | M | P | M | P |
| 50 x 40 | 900 | 0.2 | 0.3 | 0.3 | 0.4 | 0.3 | 0.5 | 0.5 | 0.7 |
| 50 x 50 | 1200 | 0.2 | 0.4 | 0.3 | 0.5 | 0.5 | 0.7 | 0.6 | 0.9 |

*M = main body of the roof P = periphery*

## 15.3.1.5.1B Pullout resistance in kN required for buildings without ceilings (but with a permeable windward wall)

cpe = -0.9, cpi = 0.2, cp = 1.1

| Purlin/ batten size | Max span | Wind Zone 0.61kPa | Wind Zone 0.61kPa | Wind Zone 0.82kPa | Wind Zone 0.82kPa | Wind Zone 1.16kPa | Wind Zone 1.16kPa | Wind Zone 1.50kPa | Wind Zone 1.50kPa |
|---|---|---|---|---|---|---|---|---|---|
| **mm x mm** | **mm** | **Low 32m/s** | **Low 32m/s** | **Medium 37m/s** | **Medium 37m/s** | **high 44m/s** | **high 44m/s** | **Very high 50m/s** | **Very high 50m/s** |
| | | M | P | M | P | M | P | M | P |
| 50 x 40 | 900 | 0.2 | 0.3 | 0.3 | 0.5 | 0.4 | 0.6 | 0.6 | 0.8 |

*M = main body of the roof P = periphery*

### 15.3.1.5.1C Pullout resistance in kN required for buildings without ceilings (and with a dominant windward opening)

cpe = -0.9, cpi = 0.8, cp = 1.7

| Purlin/ batten size | Max span | Wind Zone 0.61kPa | Wind Zone 0.61kPa | Wind Zone 0.82kPa | Wind Zone 0.82kPa | Wind Zone 1.16kPa | Wind Zone 1.16kPa | Wind Zone 1.50kPa | Wind Zone 1.50kPa |
|---|---|---|---|---|---|---|---|---|---|
| mm x mm | mm | Low 32m/s | Low 32m/s | Medium 37m/s | Medium 37m/s | high 44m/s | high 44m/s | Very high 50m/s | Very high 50m/s |
| | | M | P | M | P | M | P | M | P |
| 50 x 40 | 900 | 0.4 | 0.5 | 0.5 | 0.7 | 0.7 | 1 | 0.9 | 1.3 |
| 50 x 50 | 1200 | 0.5 | 0.7 | 0.6 | 0.9 | 0.9 | 1.3 | 1.1 | 1.7 |

*M = main body of the roof P = periphery*

### 15.3.1.5.1D Tile Batten Fastener Requirements

| Fastener | Size | No. | kN |
|---|---|---|---|
| Gun nail | 90 x 3.15 | 1 | 0.4 |
| Ringshank nail (gun/hand) | 90 x 3.2 | 1 | 0.6 |
| Gun nail | 90 x 3.15 | 2 | 0.7 |
| Twist Shank Nail | 90 x 3.3 | 1 | 0.9 |
| Purlin Screw c/s head | 10g x 100 | 1 | 2.5 |
| Type 17 screw | 14g x 100 | 1 | 7.3 |

## 15.3.2 Valleys

Valley gutters must be made of the same metal or coating as the roof tiles or a compatible material, and when the roof tile is painted or coated the valleys must also be painted.

Where secret gutters are used or where the flashings are unseen, they must have a durability of 50 years.

The valley must have a minimum upstand of 20 mm, and the fasteners must not penetrate the valley.

For valley sizing, see 5.6.1 Valley Catchment.

## 15.3.3 Roof Traffic

Metal Tiles are classified as a Type B roof cladding as they cannot be walked on indiscriminately without the risk of damage.

**Persons authorised to walk on a metal tile roof must walk only in the pan of the tile where the batten supports it, and wear flat, soft-soled shoes to prevent damage to the tiles and surface coatings.**

**Other trades must be made aware by the contractor or site supervisor of the method of walking on pressed metal tiles without causing damage, and that the cost of repairing damaged tiles is their responsibility.**

## 15.3.4 Valley Installation

See 5.6E Metal Tile Valley

*The valley boards installed between the valley jack rafters to support the valley and tile battens are required to be set with their outer edge at a minimum of 90 mm from the centre line of the valley. Valley boards are required to support a point load of 1.1.kN, which is taken to be the weight of a tradesperson with a bag of tools.*
*Valleys are installed so water discharges over the back and into the eaves gutter. The valleys are held in position by clips specially designed to allow for expansion, or by compatible nails and washers placed alongside the valley or bent over the top lip of the valley.*
**Under no circumstances must the fasteners penetrate the valley surface.**

*Joints cannot have an overlap of less than 200 mm.*
*The top end of the valley should be turned up against the hip or ridge battens to the height of the batten. Where two valleys meet over a dormer, they are cut, shaped, joined, and sealed so that they form a continuous valley.*
*The tile edge should be bent down to a minimum of 5 mm from the valley floor.*
**The gap between tiles on opposing sides of the valley must be a minimum of 70 mm.**

**Valley boards and boards supporting flashings must be H.3 treated, and all metal and timber should be separated by underlay .**

## 15.3.5 Flashings

*Standard flashings are supplied for most locations on a roof, and are in two styles, only one of which is used on any one roof. All flashings and roofing accessories are made of the same base metal as the tiles.*

- *Long accessories are 2 m long with fixing holes every 500 mm and there are specific accessories for ridges, hips, barges, aprons and walls.*
- *Short accessories are 400 mm long trims and can be used for most flashing applications on a roof.*

*Special flashings are made as required by the manufacturer or the roofer from uncoated steel, and subsequently factory coated using the same coating process as used for tiles.*

### 15.3.5.1 Ridge

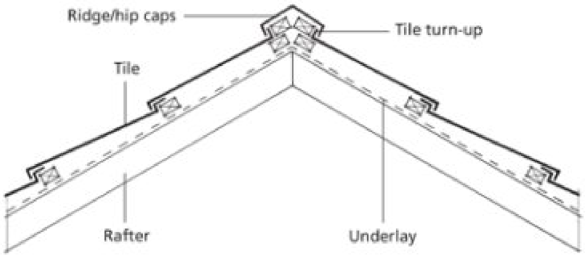
**Tiles must be turned up to a minimum of 40 mm against the battens, hip board or where they butt against**

**a vertical or an inclined surface.**

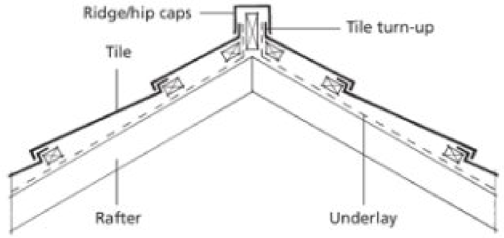
**The ridge trim cap or side flashings must cover the tile turn-ups by a minimum of 35 mm.**

Ridge tiles are bent up and then cut to form a turn-up that fits under the ridge/hip cap or short accessory. To ensure a watertight joint, a tight fit is required between the tile and the ridge cap.

### 15.3.5.1A Ridge and Hip: Short Trim Installation




### 15.3.5.1B Ridge and Hip: Long Trim Installation



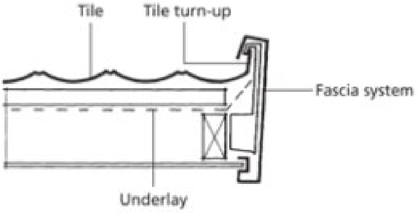

## 15.3.5.2 Hip

Tiles should be turned up against the battens or hip board by a minimum of 40 mm. See 15.3.5.1A Ridge and Hip: Short Trim Installation and 15.3.5.1B Ridge and Hip: Long Trim Installation.

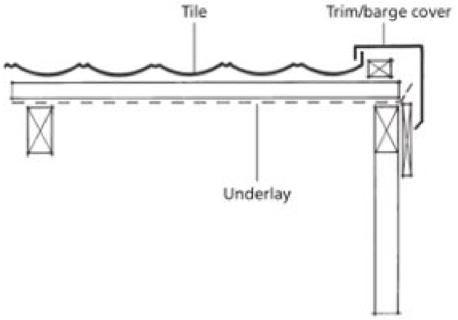
## 15.3.5.3 Gable Ends

Tile ends are turned up a minimum of 40 mm and installed against a batten that will be covered by a barge cover or under a metal fascia. If a hidden gutter is used, tile edges should be turned down into the gutter by a minimum of 20 mm.

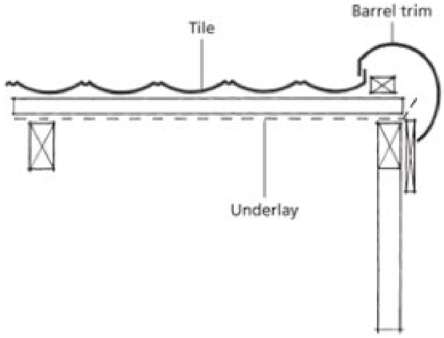
## 15.3.5.3A Tile Turn-up




## 15.3.5.3B Trim/Barge Cover




## 15.3.5.3C Barrel Trim

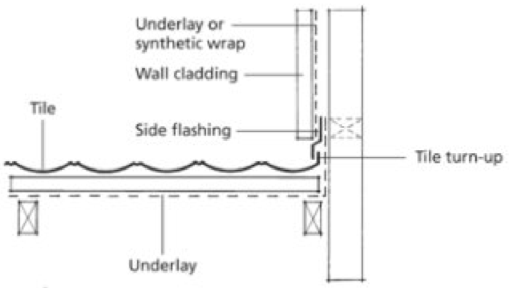


## 15.3.5.4 Flashing Metal Tile to Wall

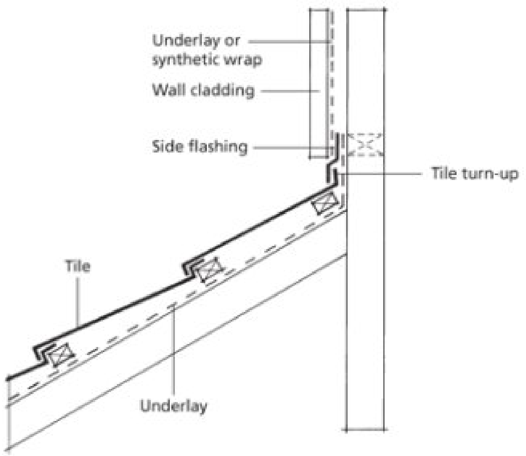
The wall cladding flashings must be positioned before the tiles and must be designed so that the turned up tile can be inserted behind the flashing.

All preparatory work of under-flashing, fixing of eaves, gutters and valley gutters must be completed, and all tiling battens must be in place before laying tiles.

### 15.3.5.4A Metal Tile to Wall



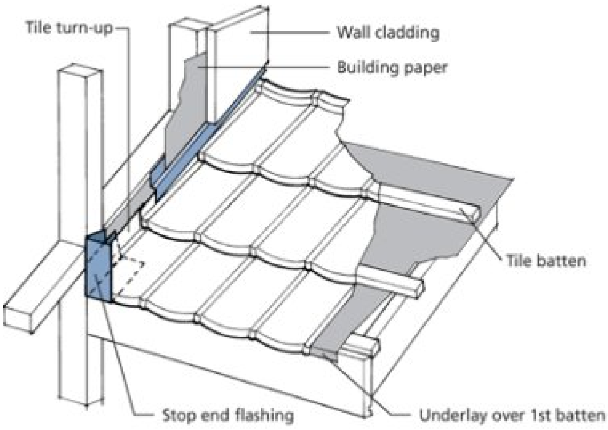

### 15.3.5.4B Pitched Metal Tile to Wall



## 15.3.5.5
## Wall To Roof Junctions

Flashings at the ends of roofs, where the roof does not end past the wall require a stop-end flashing that ensures water is directed into the gutter. Sufficient material should be left standing out from the wall so that cladding installers can ensure a weatherproof finish.

### 15.3.5.5A




## 15.3.5.6
## Penetrations

Tiles cut for penetrations through the roof should be provided with up-stands and over-flashed for drainage from above without restricting the water flow.

The flashing should finish 15 mm beyond the tile head lap above the penetration and should be wide enough to cover the nearest tile rib or up-stand. When the construction is solid masonry or brickwork, and flashings cannot be installed under the wall cladding, a chase should be cut and an over-flashing installed in the chase to provide weather protection.

## 15.3.6
## Longrun Tiles

*A long-run tile is a hybrid roof cladding providing the appearance of pressed metal tile with the fixing attributes of long-run profiled metal cladding.*

*The minimum pitch is 8°, and underlay and battens are fixed in the same manner as for pressed metal tiles.*

*The module or step size of the profile can be adjusted, and the pitch of the tile can be varied to suit any batten spacing on an existing roof or to alter the roof appearance.*

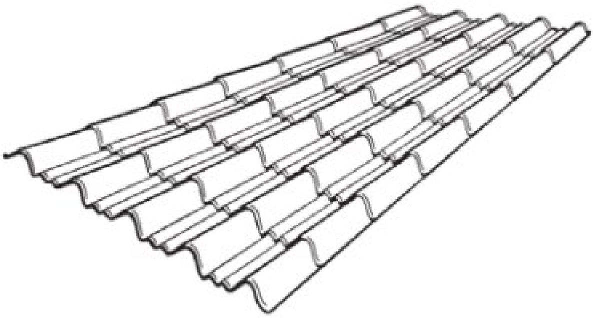
*Maximum sheet length is 7 m however transverse laps are possible.*

*The material is pre-painted metallic coated steel with a yield strength of G250 Mpa. It is fixed with nails or screws at the front of the tile.*

*Sheets should be back-laid, working from right to left which prevents creep at the gutter line due to the back-step in the underlap of the profile.*

*Longrun tile can be curved to a 250 mm radius.*

### 15.3.6A Long-run Metal Tiles



## 15.3.7 Sitework

The requirements of 13 Site Practice also apply to the installation of metal tiles. In addition all gutters, valleys, roof channels and the roof should be left clean and free from debris on completion of the work.

## 15.3.8 Laying Metal Tiles

The roofing supervisor will establish when the roof should be installed after all sub-trade work has been completed.

**All preparatory work of under-flashing, fixing of eaves, gutters and valley gutters must be completed, and all tiling battens must be in place before laying tiles.**

If substantial work, such as texturing walls, is to be carried out on a wall above or adjacent to where metal tiles are to be laid, they should be installed after such work has been completed.

Tiles should be inspected and selected, as tiles of a different colour match should not be installed on the same plane of a roof. If more than one pallet of tiles is required for one job, the colour uniformity should be checked.

**Tiles damaged during installation must be removed and replaced, and any deformed tiles or tiles with surface damage must be rejected.**

Tiles should be laid from the ridge down to avoid unnecessary traffic and can be laid broken bond or straight down the roof.

The eave gutter tiles should project over the edge of the fascia to ensure that water discharges directly into the gutter system and tiles should be laid so they prevent any water penetrating into the roof cavity.

Before tiles are laid, the direction of lay should be determined by:

- Taking into account whether the profile can be laid only one way or both ways;
- Appearance, so that laps face away from the line of sight;
- Allowing for prevailing weather exposure.

Installation of perimeter tiles (excluding eaves tiles) can be completed before the main body of tiles are laid.

## 15.3.9 Workmanship

**Graphite pencils must not be used to mark AZ coated steel products as carbon can cause premature corrosion failure of the coating.**

**Finishing of tile cuts and bends must leave straight lines up the roof section, to provide a true line for flashings.**

**When cutting tiles for their installation at ridges, hips, valleys and barges, avoid damage to the surface finish by using a guillotine or metal shears. When cutting the tile lengthwise, it must be bent before cutting to reduce the amount of distortion that occurs as the profile is flattened during bending.**

**Tiles turned up and down for ridges, hips, valleys and barges must be bent using a bender specifically designed for this purpose. Tiles must be turned up at ridges, hips and barges by a minimum of 40 mm, and down into the valleys to a minimum of 5 mm from the valley floor.**

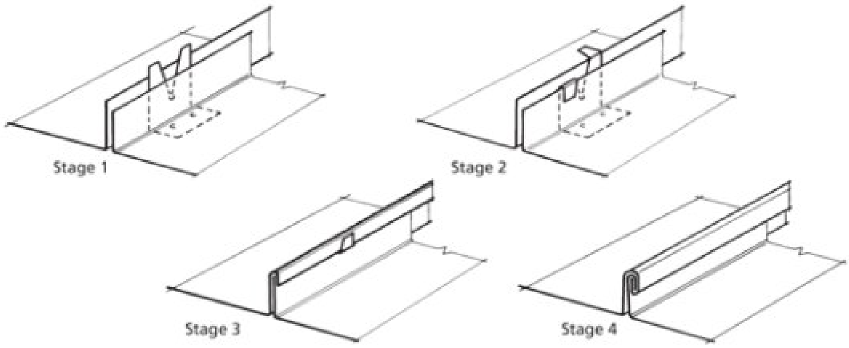
# 15.4
# Standing Seam Cladding

*Secret fixed roof and wall cladding is a type of roof or wall cladding that can be divided into two main types:*

- *Self-supporting cladding, and*
- *fully supported cladding*

*Both types are installed without visible fixings that penetrate the cladding and have provision for expansion due to the design of their clipping system. The advantage of secret fixed roof and wall cladding is that longer lengths can be used than with pierced fixed cladding and there are no exposed fixings.*

## 15.4A Jointing a Standing Seam




# 15.4.1
# Self-Supporting Cladding

*Self-supporting cladding is roll-formed with different means of interlocking the adjacent panels. It can be :*

- *spring snapped together;*
- *rotated through 180°; or*
- *machine closed in situ.*

*Where the required lengths are too long to be easily transported, and the contract warrants it, the roll forming can be done on-site to avoid damage and reduce packaging and transport costs.*

*Because there are no external fixings, the wind uplift load on the cladding is resisted by:*

- *the strength of the profile;*
- *the clip;*
- *the screws, nails or rivets, and*
- *the substrate.*

The loads imposed on the cladding are described in section 3.4.

In many cases, the uplift load that can be resisted by these component parts or the re-entrant cladding design is not as great as that for pierced fixed cladding. Designers should be aware of these limitations in high and very high wind design load areas.

The weakest parts of the clipping system are usually the clips or the clip fixing to the substrate, as the clips are secured by using screws, nails or rivets.

**Each clip must enable free movement for expansion within the clipping system. Each clip must have a minimum of two fixings, and the pull-out or withdrawal load of each fixing must exceed half that of the wind design load.**

**The fixings must be suitable for the substrate.**

**For timber the fixings should be:**

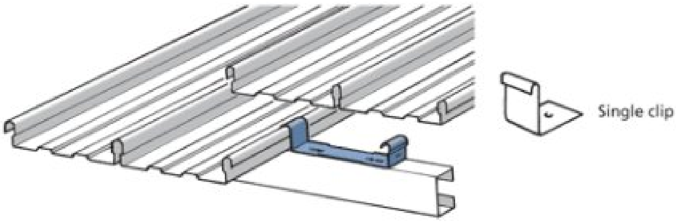
- **nails with an enhanced shank of 50 mm long; or**
- **10# x 25mm wafer head screws.**

**For steel the fixings should be:**

- **10# x 16mm wafer head screws; or**
- **12# hex head screws (where profile provides clearance).**

**Secret fix clips must not bind the cladding, as this will erode the metal and produce excessive noise. Clips must be fixed at centres determined by the panel width and the wind design load. Additional clips must be used to provide resistance to the high wind load in the peripheral areas of the roof.**

### 15.4.1A Secret Fix Cladding




Self-supporting secret fixed claddings can be curved over a radius, but as they are asymmetrical profiles, the radii should be shallow to avoid purlin creasing and panning.

Unless expansion provisions are made to positively fix elsewhere, secret-fix sheeting should be fixed at the highest point to avoid creep on steep roof slopes or due to the action of snow.

## 15.4.2 Fully Supported Roof And Wall Cladding

*Fully supported roof and wall cladding is a secret clip fix type of flat roof or wall panel, which is joined by seaming, welting or clipping and does not have any external through fixings.*

*Fully supported cladding is described as non-structural because it requires continuous underneath support, as distinct from self-supporting metal cladding which is structural.*

*Individual sheets are described as bays or panels. They are not intended to support walking loads without a structural deck of timber or rigid insulation beneath them, although some spanning support is offered by the standing seams or batten rolls. Wall details use similar detailing to roof details except that panels are positively fixed at the top.*

*The metals used for fully supported roof and wall cladding have historically been non-ferrous and have a reputation for providing a trouble and maintenance free roof, often for centuries. The methods used to fix this type of cladding are labour intensive and therefore expensive. However, fully supported cladding is a better option in terms of life cycle cost.*

*This type of cladding is termed architectural because as vertical cladding or curved roof cladding, it is a dominant feature of the architectural style of the building. Unlike modular profiled metal cladding, the width of the bays can be custom made and they can be tapered or curved.*

*Because the role of the architect or designer is expected to be more dominant, giving greater attention to detail than with other types of cladding, it is strongly recommended that early liaison occurs with designated or nominated roofing contractors.*

*Because of the skill required to install this type of roof cladding, the designer is advised to seek out a contractor that specialises in this field and whose tradesmen are capable of installing fully-supported cladding that will last for over 100 years.*

*It is impossible to detail every junction or option for fully supported cladding in this COP, but it does provide typical details.*

## 15.4.2.1 Types

*There are two types of fully supported cladding:*

- *Traditional architectural annealed metal panels limited to 1.8 m in length.*
- *Long length strip roof cladding up to 10 m in length.*

*Both traditional architectural and long length strip-roof-cladding types share the same seaming methods and also many of the same flashing and fixing details. The cover requirements may differ from profiled metal cladding because whereas profiled laps are overlapped, fully supported cladding laps are seamed.*

*When annealed grades of metal are used in short lengths, the folds can have a generous radius, because the details are hand worked and do not possess the straight lines associated with machine folded or roll formed cladding.*

The use of both types of fully supported metal roof cladding without structural ribs gives rise to undulations in the wide flat pan, which are not only to be expected but an architectural feature of fully supported cladding.

A perfectly flat metal surface cannot be obtained when using wide flat panels, and designers should be aware that fully supported roof or wall cladding will reflect light unevenly, particularly when it is new, and it will not change by increasing the thickness of the cladding.

If designer or customer expectations include flat panels without distortion, then narrow pan secret fix profiled and ribbed metal roof cladding should be considered. If wide flat panels for walls or facades without ribs are required, the COP advises using bonded panels.

*Most metals used for this type of cladding are non-ferrous and naturally weathering, and acquire a patina over time that enhances the appearance and the durability of cladding.*

*Zinc and copper can be supplied in a pre-weathered or pre-patinated finish, and this can avoid the discolouration caused during installation and the uneven colouration of individual panels in sheltered areas.*

The loadings, installation, performance, maintenance, corrosion, drainage, and site practice sections of this COP are all applicable to fully supported cladding and should be read in conjunction with this section, which contains only specific detailing and reference to fully supported cladding.

## 15.4.2.2 Traditional Architectural Metal Panels

*Traditional roofing or architectural non-ferrous metal panels have been used in short lengths for many centuries. They are associated with longevity and a distinctive architectural style. Traditional fully supported roof cladding is made from a sheet, whereas long length cladding is made from pre-formed continuous strip.*

*There are two reasons why traditional roof cladding has been restricted to short lengths:*

1. *Until the 1950's continuous strip was not available.*
2. *Fixing did not include expansion details.*

*Annealed metals used in short lengths are now limited to specialised uses – such as turrets, domes or curved structures – requiring a considerable amount of hand working.*

*The availability of metals in continuous coils has permitted the industry to take advantage of the old technology and apply it to long lengths of fully supported roof and wall cladding.*

## 15.4.2.3 Long Length Strip Roof Cladding

*Long length roof and wall cladding are roll-formed in longer lengths, generally using the same joining, fixing methods, and installation techniques as traditional roofing or architectural metal panels.*
*Long strip copper roofing systems have been used in the United Kingdom and Europe for over fifty years, and aluminium have been used in NZ for a similar length of time.*

*The main advantage of the longer lengths of the system is the elimination of cross welts on sloping roofs and of drips on flat roofs, thus effecting reductions in the labour cost of laying short lengths of metal roof cladding.*

*The length of individual panels is governed by the type of edge seam, the metal, and the provision for metal expansion of the panel. By using expansion clips incorporated in the standing seams, longitudinal movement of the panels is permitted while still providing a secure fixing to the under-structure.*

*Roll formed tray roofing panels can be varied in their width to suit the architectural design and the wind design load on the building. They can also be supplied with various upstand heights and details including locking edges similar* *to secret fixed profiles.*

*Long strip copper roofing can be laid in continuous lengths of up to 10 m long by 500 mm wide compared to the maximum 1.8 m by 600 mm bays used with traditional annealed panels. Where the rafter length is greater than 10 m, either a step or a cross-welt is required, depending on the roof pitch and the wind design load.*

## 15.4.2.4 Types Of Joints

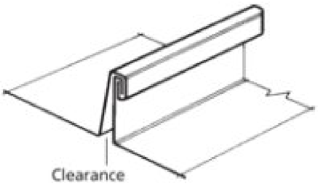
*There are three main systems used for joining fully supported roof cladding which apply to all metals:*

- *The 15.4.2.4A Standing Seam*
- *The Double seam (see 15.4.2.4A Standing Seam*
- *The 15.4.2.6A Angled Seam*
- *The 15.4.2.7A Roll Cap*

*The roll cap is a variation of the standing seam because it has two standing seams one on either side of a square or trapezoidal timber batten. The double seam and angle seam has only one seam.*

*Conical roll and other types of jointing have been used in the past, but the most common systems are outlined below. The thermal movement across the width of metal panels is taken up by the provision of a gap at the base.*

### 15.4.2.4A Standing Seam




## 15.4.2.5 Standing Seam

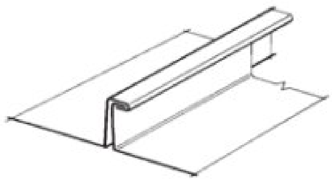
The term 'standing seam' refers to the way the panels are joined in a vertical, or "standing", position. After being laid on the substrate and clipped, it is seamed either by hand or seaming machine.

The minimum pitch of standing seams more than 30 mm in height running from ridge to eaves is 3°. The minimum pitch for standing seams less than 30 mm high is 5°. See 15.4A Jointing a Standing Seam

## 15.4.2.6 Angled Seam

*The angled seam is the same as a standing seam but has only been folded over by 90°, not 180°. It is considered only suitable for walls and pitched roofs, but not for low slope roof cladding in exposed areas.*
*The angled seam has the advantage of a more dominant and a straighter line, which is obtained by a roll forming machine rather than hand working, and it is used when the aesthetic expectations are high. The angled seam is restricted in snow areas to a roof pitch of more than 25°.*

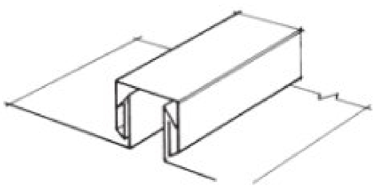
### 15.4.2.6A Angled Seam



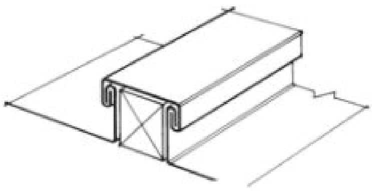
## 15.4.2.7 Roll Cap

*Roll cap systems are made from materials of a temper suitable for springing or snapping together. There are many variations, but all depend on the interlocking of a cap and the panel. Some panels have interlocking edges and do not need a separate capping.*
*When using traditional short lengths, adjacent sheets of metal are joined lengthwise using cross welts and drips for the transverse joints. These types of joints allow for expansion.*
Ridges and eaves panel fixing details must accommodate the lengthwise expansion movement of the sheeting.

### 15.4.2.7A Roll Cap



### 15.4.2.7B Seamed Roll Cap



*Batten rolls running from ridge to eaves can be used on all roofs were the minimum pitch is 5°.*

## 15.4.2.8 Transverse Laps

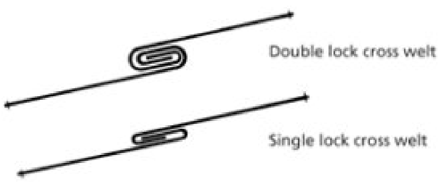
**The transverse seams on standing seam roofs with a pitch of less than 20° in areas of high or very high wind design loads, must be soldered or sealed.**

**A double lock cross welt transverse joint must be used for joints on roofs with pitches of more than 7°, and single lock cross welts must be used on pitches above 25° or on vertical surfaces. The double lock cross welt must be used in all cases where severe weather conditions exist.**

**The maximum length for roof pitches of less than 30° must be 10 m. Where a roof slope exceeds 10 m, a 50 mm deep step flashing must be placed at regular intervals to provide for panel expansion in the direction of the fall.**

The double lock cross welt should be used in all cases where severe weather conditions exist. Where the pitch is below 20°, the edges of the metal forming the double lock cross welt should be soldered or sealed with silicone sealant before closing the welts and seams and folding together.

### 15.4.2.8A Locked Cross Welts




*Cross welts used with standing seams should be staggered in adjoining bays to compensate for the increase in thickness of many-layered metal, but batten roll joints from ridge to eaves may be used in a continuous line across a roof.*

*Although a long strip roof can be laid entirely using conventional hand tools, power or hand operated machines are used on long panels to save time.*

*All joints in weathering details for penetrations, rainwater heads, stop ends, and expansion flashings in sheet copper should be sealed by brazing with silver solder. In zinc, all joints should be sealed using lead/tin soldering. All metals should be mechanically locked before sealing.*

**All transverse and longitudinal joints on fully supported metal roof and wall cladding must only be welted, lock seamed or capped, and must not be joined solely by soft soldering, welding or brazing.**

**Where the direction of fall is diagonal to the standing seam and welts, the laying direction of the bays must be away from the flow.**

Where rainwater will drain to one side of the bays, high-velocity streams of water flowing down the seams and welts should be directed away from the seamed side of the panel.

Light gauge wide pan widths should be avoided because they give rise to sheet drumming and consequential fatigue.

## 15.4.3 Standing Seam Materials

*Metals used in traditional architectural panels and used as fully supported cladding include lead, annealed copper, zinc and aluminium.*
*Metals used in long length architectural panels, however, generally use a harder temper or alloy and include copper, zinc alloyed with titanium/copper, aluminium, stainless steel, and plain and pre-painted AZ coated steel.*

*The metals described in 15.4.3 Standing Seam Materials are suitable for long length fully supported cladding.*

*Copper, aluminium and stainless steel can be supplied with an embossed surface finish, which not only reduces glare but can also provide additional strength.*

### 15.4.3.1 Copper

Roof cladding, gutters, and expansion and fixed clips should be made from a minimum of 0.6 mm half-hard temper strip, conforming to the British Standard, BS 2870.

Roll formed panels using secret fix interlocking edges that are made from half-hard temper, should not be silver soldered or brazed, because the heat required will anneal the copper.

When softened areas in half-hard copper can develop differential stress patterns, caused by expansion, which can result in fatigue and eventual failure of the metal.

Where penetration or other flashings require an amount of workability or are to be silver soldered or brazed, they should be made using fully annealed copper sheet or 0. 6 mm thick strip. See 4.17.5 Copper.

## 15.4.3.2 Zinc

Zinc roof panels and flashings should have a minimum thickness of 0.7 mm, although heavier gauges are used.

Copper and titanium are alloyed with 99.995% pure zinc to provide additional strength. See 4.17.4 Zinc.

## 15.4.3.3 Aluminium

*There are many aluminium alloys available for use in roof cladding, and roll formed panels can be made from soft, 1/2 hard or 3/4 hard tempers with a minimum thickness of 0.7 mm. See 4.17.3 Aluminium*
*Pure aluminium strip (99%), known as 'dead soft', is used for flashings in widths between 150 mm and 600 mm in thicknesses of 0.30 mm, 0.45 mm, 0.55 mm, and 0.70 mm.*

## 15.4.3.4 Stainless Steel

*Stainless steel has a higher strength than most other metals and can be used in a lighter gauge or thickness. It is compatible with copper but should be used with caution with other metals. See 4.10.3 Compatibility Table.*

## 15.4.3.5 Coated Steel

*Metallic and organic coated steels can also be used for fully supported roof and wall cladding. They require the same treatment as self-supporting roof and wall cladding and the same design criteria as for other metals. See 4.17.1.1 Metallic Coatings and 4.18 Organic Coating.*

## 15.4.4 Loadings

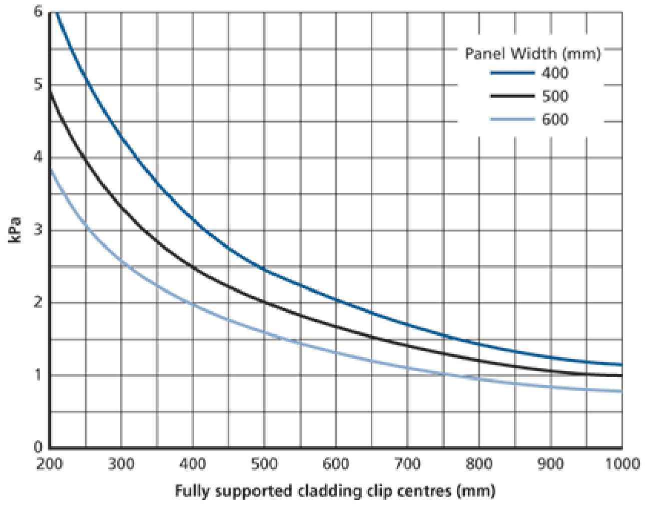
*The uplift forces on fully supported roof cladding are transferred through the building through the clips and fasteners to the substrate.*

*The performance criterion is the number of clips or fasteners per square metre, which can be varied by the spacing of the clips or the width of the bays. The withdrawal load of the fasteners depends on the metal, shank diameter, shank type, penetration depth, and the type and thickness of the substrate.*

*The design load capacity of a clip can depend on the material of the clip and the thickness of the substrate.*

**The clips and fasteners should be able to withstand the wind design load, measured in kilonewton (kN), which is derived from the square measure of kilopascal (kP).**
**Maximum clip centres for different wind loads shall be derived 15.4.4A Load/Clip Spacing, after making provision for local pressure factors.**

## 15.4.4A Load/Clip Spacing




To improve the uplift resistance of fully supported roof cladding, the design options are:

- reducing the width of the end bays;
- increasing the metal thickness; and
- placing the clips closer together.

The clip spacing is determined by the wind design load, the thickness, type of substrate and the holding strength of the nails or screws. To comply with the wind design load criteria, the withdrawal load of the clip/nail assembly should be known for the thickness and type of substrate.

**Gable or verge panels must be wider than 400 mm, and the clips must be fixed closer together on the edges of all roofs in high wind design load areas.**

*Unlike profiled metal cladding, the point load imposed on fully supported cladding is supported by the substrate.*

## 15.4.4.1 Fixing

**Smooth shank nails must not be used for fixing clips as they do not comply with the loads given in 15.4.4A Load/Clip Spacing**

*Hand or gun-driven screws both provide better performance and are the preferred fixing. The depth of penetration is a major performance factor when considering the wind design load.*
*Ideally, clips should be positioned to coincide with sarking support positions.*

## 15.4.4.2 Substrate

When plywood substrate is used beneath fully supported roof cladding, it should be smooth and dimensionally stable, with a moisture content of less than 18% and made windtight. All screws should be countersunk to prevent damage to the metal cladding.

Plywood with a minimum thickness of 12 mm should be fixed to the framing at 600 mm centres, with 40 mm x 8# countersunk screws at 150 mm centres around the panel edges and 200 mm centres on the intermediate supports. The fasteners should not be closer than 10 mm to the edges.

Although 17.5 mm plywood will span 1200 mm, the length of the fasteners should be increased proportionately.

A 3 mm expansion gap should be provided between sheets and a nail or screw can be placed in the gap and be used as a spacer for this purpose. All joints should be staggered and taped over before placing the underlay.

Framing centres should be designed to withstand the increased loads at the periphery of the building.

**Ventilation must be provided for all fully supported roof designs using plywood substrate. See 10.6 Ventilation.**

**CCA treated plywood must not be used under zinc, aluminium, metallic coated or prepainted steel cladding without an underlay complying with 11.5.1A Underlay Suitability or without being separated by an underlayment as described in 10.7.5 Non-Residential Buildings. Provision must be made for adequate ventilation under the sarking.**

**Where the design wind load is higher than 1.5kPa, the minimum fixing centres for 12 mm ply substrate must be 400 mm.**

## 15.4.4.3 Fasteners

*For specification of clips and cleats see 8.7.3 Secret Fixing Clips*

### 15.4.4.3A Zinc or Aluminium

***Nails:** stainless steel or hot dipped galvanised enhanced shank nails 25 mm long.*

***Screws:** stainless steel or hot dipped galvanised countersunk 25 mm long x 8#.*

## 15.4.4.3B Copper

*Nails: copper or stainless steel 25 mm long x 2.6 mm barbed shank flatheads.*

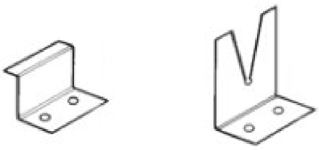
*Screws: Stainless steel countersunk 25 mm long x 8#.*

## 15.4.4.3C Clips

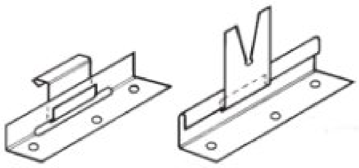
*Two types of clips are used:*

- *fixed clips; and*
- *expansion clips.*

## 15.4.4.3D Fixed Clips



## 15.4.4.3E Expansion Clips

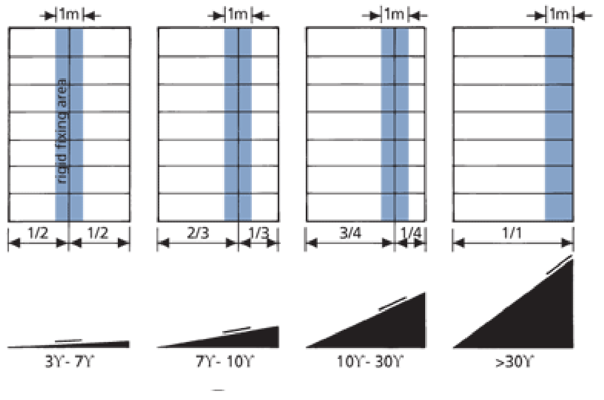


Standing seams up to 3 m long may be secured entirely with fixed clips, but for longer lengths than 3 m, expansion clips should be located above or below the fixed clips to allow for longitudinal movement of the panels.

Fixed clips should be positioned at centres dependent on the design wind load. See 15.4.4A Load/Clip Spacing.

The position of the fixed clips depends on the roof pitch. On a pitch of more than 30°, the clips should be placed at the top of the slope.

### 15.4.4.3F Clips Positioning Determined by Roof Pitch




## 15.4.5 Underlay

**All fully supported metal roofs must have an absorbent and permeable underlay to absorb condensation. Underlay must be laid as detailed in 10.7 Underlay and must be covered on the same day.**

**The permeable, absorptive felt or paper underlay should be laid before starting any metal work, and it should be of a type that will not adhere to the metal cladding under temperature changes**

*The underlay :*

- *allows the passage of water vapour;*
- *lessens the possibility of abrasion between the metal and the decking;*
- *absorbs condensation;*
- *deadens the sound of wind and rain; and*
- *separates metal cladding from timber treated with copper preservative.*

## 15.4.6 Ventilation

**All fully supported metal roofs must have provision for ventilation of the timber substrate to allow dissipation of condensation.**

*Copper is not corroded by retained moisture, but most other metals can suffer degradation from continued exposure to moisture. Zinc is particularly prone to corrosion, but zinc coil is available with a high-build lacquer or specially treated underside to avoid the effects of retained moisture. Where the design is likely to cause continued moisture or cannot provide sufficient ventilation, enhanced underside treatments should be considered for zinc.*
The best provision is always to provide sufficient ventilation at the eaves and ridge, and the minimum of a half an air change per hour to ensure that any condensation is not retained. Proprietary vents made from aluminium or polyethylene can also be used at one per 50m2. These should be placed over a purpose made hole or at the intersections of the 3mm gap between the plywood sheets. See 10.6 Ventilation.

## 15.4.7 Drainage

### 15.4.7.1 Valleys

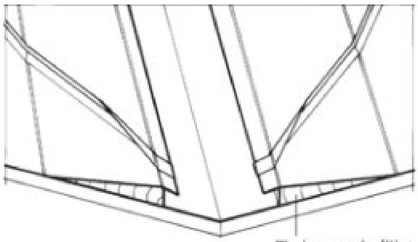
Fully supported valley gutters should comply with 5.6 Valley Gutters.

Where a valley is formed between two roof slopes, a separate valley gutter welted to the roof sheeting should be used.

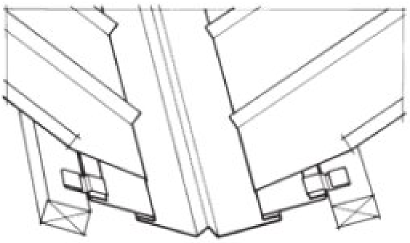
Jointing between the valley gutter and roof sheeting can be carried out by two methods:

- By dressing over an 15.4.7.1A Angled Timber Fillet with a single welt on the top front edge of the fillet. This detail is not suitable for high or very high design wind loads.
- By forming a 15.4.7.1B Re-entrant Fold in the valley to accept the panel turn under.

#### 15.4.7.1A Angled Timber Fillet




#### 15.4.7.1B Re-entrant Fold



Valleys should be secured using clips with a minimum of two fasteners, installed parallel to the valley, and be formed from at least the same gauge metal as is the valley metal flashing.

Securing clips with two fasteners side by side holds the clips in place more securely than using one fastener per clip; with only one fastener, cyclical thermal movement of the valley metal will loosen the fastener, and the valley can bind against the misaligned clips.

The back tab of a clip should be bent over the fastener heads, and the tab flattened, to keep the fasteners from backing out and from damaging the underside of the metal roof panel.

Because valleys attached with clips can move within the clips due to thermal expansion and contraction and slip downslope with time, the head of the valley should be securely attached to the substrate. A raised centre within the valley flashing allows for some expansion and prevents water flow running across the valley from one side to the other. See 15.4.7.1B Re-entrant Fold.

**Where a valley drains from a dormer roof and the capacity of the panel or bay does not equal the discharge, it must be spread over two or more bays. See 9.9 Dormer Junctions.**

## 15.4.8 Facade Cladding

Fully-supported facade or wall cladding is used for architectural effect. The width of the panel and the metal thickness can be different from those used for roof cladding. As flat panels do not have a perfectly flat surface, and to improve its visual effect, the maximum panel width should be restricted to 500 mm, and a maximum of 400 mm for panel lengths over 5 m.

The substrate should be true and in line. Any defect will show and care in seaming is necessary, particularly at the clip positions. To avoid large flat areas, panels can be divided into smaller lengths by single welts, by varying the length or using a diagonal pattern. New panels require precise and clean preparation of the individual components by skilled tradesmen before completing the patination.

Special care is needed for the storage of the panels, flashings, and components to avoid dirt and staining.

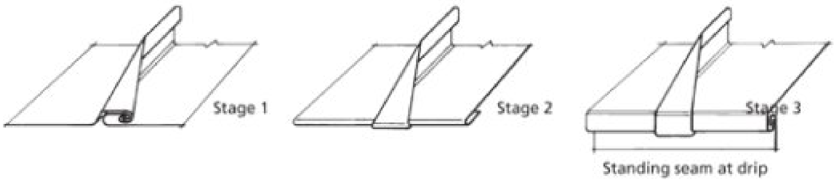
## 15.4.9 Edge Finishes

*Because the standing seam or the batten roll should terminate at the peripheral areas on the roof, this detailing will be determined by the type of intersection.*
*The three considerations are:*

- *Weathering.*
- *Expansion.*
- *Appearance.*

**All flashing intersections must be made weatherproof without primary reliance on sealants. Provision must be made for expansion in two directions; acceptable joints are shown in the drawings shown in 11.8.**

### 15.4.9A Standing Seam Edges




*Three stages in preparing standing seam for cross welt at drip, ridge, apron or junction to valley gutter.*

*A double standing seam can be turned down through 90°, 150 mm from the eaves, with the folded side uppermost, and the end of the turned down standing seam folded into a cleat, drip or valley.*
When the sheet is engaged into the folded edge at the stepped fall, an allowance should be made to allow for thermal expansion.

The turned down edge of the bay should not be able to disengage itself from the eaves flashing during thermal expansion, and there should be sufficient room to allow for free contraction of the pan or bay.

*The double seam does not need to be folded over in roofs with pitches greater than 30° as the eaves flashing will prevent any ingress of moisture. The double seam is cut at the eaves, and only the end of the sheet is engaged in the eaves flashing.*
*The double standing seam with a splayed or angled lower end is the most demanding end detail, but it is the most visually acceptable.*

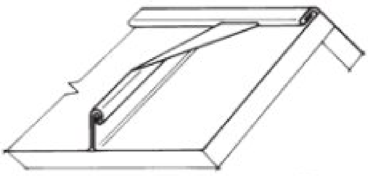
## 15.4.9.1
## Ridge And Hip

The method that is used to finish the ridge and a double standing seam depends on whether the type of ridge detail is vented, has a separate ridging, is welted, and whether it is a standing seam or a roll.

Where the panel passes over the ridge or hip of a roof, a roll not less than 38 mm higher than the intersecting rolls or standing seams should be provided. The ridge roll should be undercut to accommodate thermal movement of the panels.

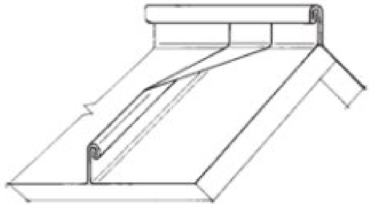
An alternative edge finish is to flatten the seam similar to that shown in 15.4.9A Standing Seam Edges

### 15.4.9.1A Welted Ridge

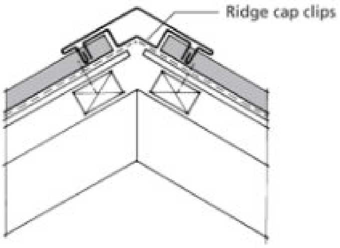


### 15.4.9.1B Standing Seam Ridge



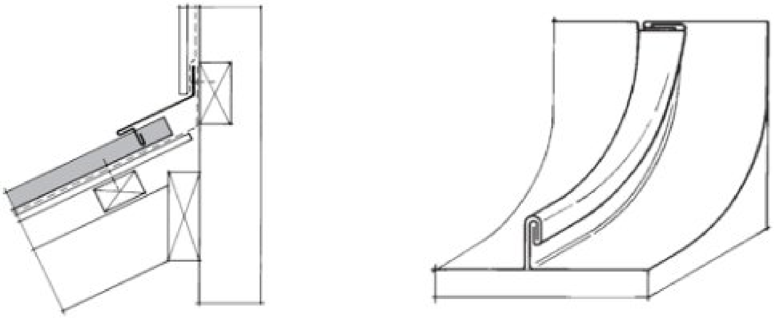
### 15.4.9.1C Separate Ridge




## 15.4.9.2 Apron Or Abutment

*Where the panel terminates at a wall, there are many different details some of which are similar to those required at the ridge.*

### 15.4.9.2A Standing Seam Abutment



Aprons and flashings to walls and upstands should consist of an independent, preformed strip of metal of not more than 1.8 m in length, welted to the roof sheet or cover flashed to give a minimum 100 mm cover to the vertical upstand.

Where a standing seam meets an abutment, the standing seam can be finished as for profiled metal roof cladding with an apron or the end of the seam can be flattened to facilitate folding the metal to form the upstand.

At the highest point of the roll, where it meets an abutment, the sheet is dog-eared to form a corner, and the upstands are welted to the capping and cover flashing. See 15.4.9.2A Standing Seam Abutment.

Where an apron abuts a block or brick wall, the cover flashing should be folded a minimum of 25 mm into the wall chase with a 10 mm hook wedged into the chase and pointed with a flexible sealant or cement. All free edges should be stiffened as described in Flashings and when retained within a cleat the edge should be free to provide expansion. See 8.3.2 Flashing Edges.

## 15.4.9.3 Eaves And Verge

Joints at eaves and verge edges should provide a secure, wind tight termination for the roof, but be capable of accommodating the thermal movement of the panels without overstressing the metal.

**Expansion provision must be made at eaves and verge edges and at the joints.**

### 15.4.9.3A Eavea and Verge Expansion Provision

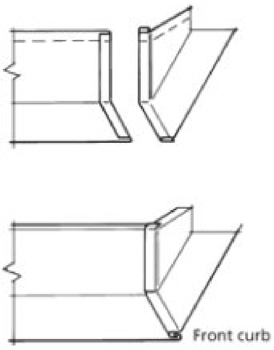
## 15.4.9.4 Penetrations

**Penetration flashings for fully supported metal roof cladding must be installed by the roofing contractor only, and other trades must not cut any hole in fully supported metal roof or wall cladding.**

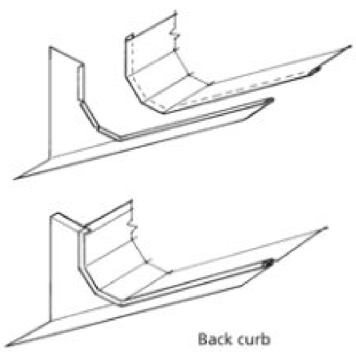
Penetration flashings used in conjunction with fully supported metal roof cladding require specialist detailing. The details for weathering penetrations in fully supported roof cladding that are included in this section should be read in conjunction with section 9 *External Moisture Penetrations*

The back curb of the flashing upslope from the penetration should be installed under the roof panels, and the front apron of the flashing should be installed over the roof panels.

### 15.4.9.4A Front Curb




### 15.4.9.4B Back Curb



The designer is responsible for coordinating the penetration location to be sure that a penetration will not coincide with the panel seams.

When the penetration is less than 50% of the width of a panel, the hole can be weathered by using a fabricated flashing made by forming an upstand by soldering, welding or sealing.

*Small pipe penetrations that can be installed within the width of the individual roof panel can be weathered using an EPDM proprietary flashing as described in 9.6 Boot Flashings These are not the preferred option as the expected life of these flashings is unlikely to equal that of non-ferrous fully supported roof cladding. Shop fabricated flashings may require a conical metal rain collar or a 'Chinese hat' to provide sufficient movement if the pipe is sleeved or insulated.*

Large penetrations are more complex and require additional considerations during design and installation.

Regardless of the penetration size, weatherproofing should be achieved without relying solely on sealant and independent movement of panel and penetration should be allowed for.

When the penetration width is over 600 mm the panel ribs should be stopped short of the upslope face of the curb, so that water can flow past the ends of the ribs and not be trapped against the curb.

Large penetrations that require flashing through the panel ribs and are over 600 mm wide should be factory manufactured to a cricket design as described in *section 15.8.*

*Flues should be terminated at a sufficient height above a metal roof and discharged in such a manner as to ensure that concentrated flue gases do not come in contact with the cladding.*
*Dormer windows, chimneys, vents and other penetrations projecting through the roof can impede drainage and require special design. (9.9 Dormer Junctions)*
*The majority of flashings are made from fully annealed or dead soft metal, but where rigidity or a straight line is required, only half-hard grades of material should be used.*

## 15.4.9.5 Cappings

*All capping details should allow for expansion and be the same as those detailed in 8.4.3 Parapet Cappings Cappings can be welted to the upstands of panels instead of using through fixings.*

## 15.4.10 Durability

*Corrosion can be caused by using dissimilar metals in contact with, or run-off from, other roof cladding materials.*
Designers and tradespeople should be aware of the electrolytic corrosion that can take place when small particles of metal are deposited on another metal, and when the same tools are used with a variety of metals. See 4.10 Compatibility.

For maximum durability, no water should be allowed to penetrate between stacked panels, strips, profiled sheets or coils during storage and transportation. In high humidity with the simultaneous exclusion of air, white rust will develop on the surface of zinc and zinc coated cladding, and aluminium and copper will also suffer permanent staining. All metals in storage should be kept dry. See 13.4 Acceptance Of Materials.

## 15.4.10.1 Patina Formation

Metals and metal alloys used for the fabrication of architectural roof panels and accessories are often those that are naturally weathering and whose surfaces develop a layer of protection upon exposure to the elements. Aluminium, copper, lead, stainless steel, and zinc are all naturally weathering.

A naturally weathering metal forms its own protective layer by oxidation, sufficient to withstand environmental exposures and to develop oxidation layers that are durable and well-bonded to the base metal, with minimum porosity and minimum solubility in water. This weathering and subsequent oxidation can result in a different colour and appearance as well as protecting the metal.

## 15.4.10.2 Copper Patina

*Upon exposure to the atmosphere, copper develops a protective film called patina, and its composition depends on varying regional atmospheric conditions.*
*In industrial and urban atmospheres it consists mainly of basic copper sulphate, and in non-urban environments it consists of basic copper carbonate. These copper salts have chemical compositions similar to those found in natural minerals, and once the patina has developed, no further copper corrosion occurs under normal conditions, As it is self-healing, any superficial mechanical damage is repaired by the renewed formation of patina.*

*The patina, consisting of green copper salts, is often described as verdigris which is inaccurate, as verdigris is caused by the chemical reaction of copper with acetic acid.*

*In contrast to copper salts, which form a natural patina, verdigris is water soluble and is visually recognised by its strikingly green colour.*

*Atmospheric corrosion of copper occurs at 2-3 µm per year depending on the environment, but this rate is applicable only during the first few years and with time it decreases until it reaches zero after 70 years.*

*Copper components exposed to the atmosphere undergo various stages of discolouration from the time of installation to the development of the natural patina. Minor marking will become invisible as copper develops its primary protective film, a uniform brown oxide, after a few weeks due to the reaction with atmospheric oxygen. The intensity of the brown colouration increases with time until the patina develops as a secondary layer of various shades of green.*

*This is caused by various copper salts and depends on prevailing local atmospheric conditions, exposure to moisture and air pollutants, the pitch of copper roof or wall areas, and on time. The composition of the atmosphere dictates the rate of patina development and the following periods are considered normal for the formation of the protective patina film:*

- *Moderate – 18 years.*
- *Industrial – 10 years.*

- *Marine – 5 years.*

*In mild environments, it may take over 30 years to turn green and in some dry environments, it may never turn colour.*

*Strength properties and the degree of purity of the copper do not affect the rate of patina formation.*

*In some locations or positions, the slope of the roof, or vertical surfaces or soffits, can affect the development of the patina to the degree that copper may never turn green.*

*Copper can be pre-patinated or patinated after installation, and these field methods may provide rapid patination, but the resulting colour can vary significantly.*

*Patination can be affected by any streaking, marking, or soiled areas or by perspiration caused by handling, which can be avoided by the use of cotton gloves during installation.*
*Water run-off from copper can visibly stain light-coloured building materials, such as concrete, brick and stone.*

## 15.4.10.3 Zinc Patination

*The chemical process which results in the formation of the protective film on the surface of zinc has several stages and may take a long time to develop, depending on the season, weather and other factors.*

*During this transitional phase, the surface appears to be irregular due to light reflection. As patination progresses these reflections will disappear; the greyish blue protective film will become denser and the colour more uniform. Patination can be artificially accelerated and Titanium Zinc can be supplied pre-weathered to prevent any difference in appearance of adjacent panels.*

*Unwashed areas of zinc and aluminium cladding can show an uneven and patchy surface film when they are in an aggressive environment. Maintenance is required as for other metals.* *See 16 Maintenance .*

# 15.5 Insulated Panels

## 15.5.1 Design

*The use of double skin composite or insulated panels for roof and wall cladding requires the same or similar detailing for flashings, penetrations and design considerations as those for single skin roof and wall cladding described in this Code of Practice. Reference should be made to the relevant section when designing insulated panel systems, as this section only describes specific differences.*

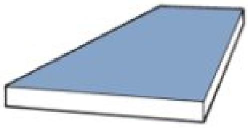
*Because insulated roof and wall panels are specialised proprietary systems, few specific details are discussed. However, the principles of water shedding, fastening, and maintenance described in this COP are all applicable.*

*Composite or insulated panels are factory made laminated products, using different core materials permanently bonded by adhesive or foaming to act as a single structural element.*

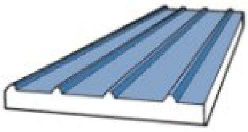
*Insulated or sandwich panels have metal facings on both sides; the space between them filled with an insulating core which is permanently bonded to both surfaces.*

*Three types of sheeting are used on insulated panels.*

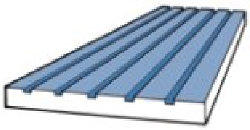
### 15.5.1A Flat Metal Panels (Cool Room)



### 15.5.1B Profiled Metal Panels (Roofing)



### 15.5.1C Miniature Ribbed Panels (Architectural)



*The manufacturing process for bonded panels consists of roll forming the flat or profiled sheeting, followed by the adhesion of the insulation core to both surfaces or skins.*

*There are three methods to do this :*

- *Continuous metal panel production by bonding panels of insulation to metal skins.*
- *Individual panel production.*

- *Continuous metal panel production by foaming.*

*Site assembled, or built-up systems are also known as composite panels and are of two main types.*

- *Two profiled sheets have rigid insulation boards adhered to their troughs, without metal spacers.*
- *The sheeting is mechanically fixed on both sides to a structural girt. The girt can form a thermal bridge unless spaced away from the structure. This type of built-up system commonly uses fibre insulation.*

*Bonded composite panels develop their strength from the sandwich of skins and insulation, and are made with a tongue and groove side lap detail that incorporates concealed fasteners.*

*Flat continuously produced panels suffer minor undulations in the metal skins that arise from built-in tensions in the metal coil and introduced during panel manufacture. Panning can be minimised by using an embossed or matt finish or forming minor ribs or swages on the flat face of the panel.*

## 15.5.2 Materials

*The facings or skins of composite panels can be metallic coated, or pre-painted steel or aluminium and are either profiled or flat on either or both sides. The internal skin is also known as the liner skin or sheeting.*
*The metal facing or skin is commonly made from grade G300 steel of 0.40 – 0.63 BMT thickness, with pre-painted organic finish over a metallic coating of ZM 275.*

*Aluminium facings are used in very humid conditions or a severe marine environment and can be supplied with a mill surface, embossed surface, or they can be pre-painted.*

## 15.5.3 Insulation Core

*The bonded insulation core material contributes to the panel strength by providing most of the resistance to shear forces, and the depth of the core determines the panel's resistance to deflection.*
*The core can be made from different types of material all with different insulating values, fire ratings, and strengths. The most common are EPS Expanded Polystyrene, PIR Polyisocyanurate, and PPS Phenolic/Polystyrene.*

*Expanded polystyrene is used for flat factory bonded panels and can be shaped to the profile of the top skin.*

*The insulation thickness of a profiled roof panel varies from 30 mm – 300 mm. To achieve the same insulating value as a flat panel, the profiled roof panel needs to be thicker.*

*Dense rigid mineral-fibre insulation may be selected for applications where fire resistance or acoustic insulation properties are considered to be most important.*

*Built up or composite panels insulated with extruded closed cell polystyrene or fibre insulation material may need to be of a different thickness to achieve the same insulation value.*

## 15.5.4 Structural

*Composite panels are integral units in which the insulation layer together with the two metal skins act as a beam to resist wind and point loads.*
*The synergy acquired by the combined strength and stiffness of the metal and insulation core is far greater than the sum of the component parts and large spans are possible. The strength and stiffness of insulated panels are determined by both the metal and its thickness, and the core material and its thickness. Using profiled sheeting for one or both faces can further increase the strength, and increasing the thickness of the core permits using larger spans under the same loading conditions.*
*The number and strength of the fasteners under wind suction loads can limit the maximum purlin spacing. If roof-lights are required, the maximum purlin spacing will be limited by the strength of the roof-light sheeting. Polycarbonate or G.R.P. barrel vault roof-lighting may avoid this restriction.*

*Insulated panels, unlike single skin profiles, can support normal foot traffic without damage, because the foam core provides continuous support to the external sheeting to resist deformation and indentation.*

All persons walking on the cladding should wear footwear suitable to comply with the safety requirements in 13.1 Safety, and also to avoid marking or scratching the surface coatings.

*Structural bonded composite roof panels contribute to site safety because, once fixed, they provide a safe working platform. Fixed panels are fully trafficable at all practical spans, foot traffic on unfixed panels, however, should be restricted to the roof panel erectors.*

## 15.5.4.1 Supporting Structure

Composite panels are supported on purlins or girts, which should be accurately erected to a maximum tolerance of 3 mm and L/600; due to their inherent stiffness, insulated panels do not have the flexibility to follow uneven structures.

*Where composite roof panels are required to have end-lap joints, the external sheets are overlapped, and the joint in the lining and insulation is a butt joint. As both sides of the joint require support, and the fasteners are at one side of the joint, the purlins should be wide enough to provide this support.*
*All transverse laps should be fixed and sealed to prevent the passage of air, water or water vapour.*

*If composite panels are expected to provide restraint to the purlin or girt flanges, through fixing with oversized holes is required which allows panels to slide under thermal movement, as clips do not provide sufficient restraint. Where fixings are widely spaced panels may not effectively restrain the purlin or girt flange.*

Composite panels should not be used in lieu of sag bars as their function is to hold the purlins or girts in their correct location while the panels are erected.

*Composite panels have a structural integrity which single skin profiled sheets do not possess, and can accommodate penetration openings of 350 mm diameter or 300 mm square without the need for additional structural supports or trimmers.*
Where larger holes are required trimmers should be in place before the erection of the panels.

## 15.5.5 Thermal

*Thermal bowing can occur when the two skins are at significantly different temperatures such as north facing walls, e.g., when a coolroom roof panel is in direct sunshine. The effect is accentuated when the external surface is a dark colour and is more severe for aluminium facings.*
*A method of limiting the thermal bow is to make stress relief cuts in the panels as follows.*

1. *When a panel is restrained at three or more points, a cut completely severing the cold skin may be required at the intermediate point.*
2. *When a panel is attached along its edge, a partial stress relief cut may be required.*

*The through fasteners or fixing clips are cold bridges, but it has been shown that these are unlikely to increase the U-value by more than 1 –2 %.*

*A joint may be required when the roof panel is longer than 15 m. It can be a sealed lap joint with provision for expansion, or a stepped or waterfall detail. See 8.4.4.3 Step Apron.*

### 15.5.5.1 Fire

Most panels have a fire resistance when used as a non-loading panel, and the cores are made from insulating foam incorporating fire retardant materials. Fire regulations aim at reducing the risk of death or injury to occupants, the public and the fire service, and it is achieved by the selection of materials which behave in a predictable manner.

**Steel and aluminium liners achieve classifications for combustibility, ignitability, and surface spread of flame; for fire resistant wall construction, steel-skinned composite panels must be used because the melting point of aluminium is too low.**

**Polystyrene cores are not easily ignited behind the metal skins but can melt and flow out of the panel. Such cores must not be used for internal partitions or ceilings, where there is a high fire risk. Polystyrene cored panels must be isolated and protected from radiation from hot flues.**

Once a fire has started within the foam core, fire services are unable to trace or extinguish it and the building should be regarded as unsafe.

Because nylon bolts may jeopardise the integrity of the building during a fire, other mechanical connections should be used if the building is required to have a fire rating or is considered a likely fire risk.

N.B. Fire ratings are available for non-load bearing applications.

**Aluminium-skinned composite panels, nylon bolts or polystyrene cores must not be used where the building is required to have a fire rating or is considered a likely fire risk.**

## 15.5.6 Condensation

*Metal facings are effectively impervious to penetration by vapour, while polystyrene insulation has a closed cell structure which does not permit significant transmission of vapour. Interstitial condensation cannot occur without the presence of vapour in the insulation; to prevent this it is necessary to seal all laps and gaps.*
*The side-lap joints require sealing to prevent condensation on the overlapping edge of the external sheeting.*
*Transverse laps, joints and ridges should also be fastened and sealed.*
*When composite panels are used as cold store insulation a complete and continuous vapour barrier is essential to prevent inward moisture vapour pressure. Any discontinuity will result in a build-up of ice which can destroy the panel.*

## 15.5.7 Acoustic

*Acoustic insulation properties are related to cladding mass, and as composite panels are relatively light, they do not have inherently good acoustic insulation properties. They can be installed with sealed joints to reduce airborne sound and can perform as well as some built-up systems.*
*Acoustic absorption depends on the nature of the lining. Flat metal linings absorb very little acoustic energy, and it may be necessary to install additional acoustic lining systems.*

## 15.5.8 Fixing

*Composite roof panels with trapezoidal ribs are through-fixed with a load spreading washer on the rib and require sealing at the side-laps. Flat concealed fix composite panels require more complex jointing systems.*
*Profiled cladding side laps require stitching at the rib at 500 mm centres with a strip sealant of approximately 9 mm x 3 mm or similar. See 8.5.2 Secondary Fasteners.*

*The through fixings may also be pan fixed or located on a mini-rib or swage within the trough, but purpose-designed fasteners are required to maintain the weather seal between the metal skin and the washer. Pan fasteners should not be over-tightened as this causes shallow dents around the fastener head and washer. The washer should have a minimum diameter of 25 mm to provide good pull-over strength.*

**All fixings must have a pullout strength and frequency to equal the wind design load. See 3.12 Fastener Performance.**

*The maximum practical length of panels is restricted to approximately 25 m, because the weight of greater lengths may present handling problems. Where a transverse joint is required, there are two options.*

1. *At end-laps, the lining and insulation is butt jointed over the purlin, and a 150 mm overlap is formed in the external weather skin only using two lines of sealant. The sealant should be silicone or preformed strips and positioned at the top and bottom of the lap. To provide a secure seal with flat or wide pan profiles, additional sealed rivets or stitching screws are required through the top skins only. This detail is only suitable where the roof pitch is more than 10° and where the maximum length is less than 1 5 m.*

2. *Where the pitch is below 10° or the length is more than 15 m, a stepped or waterfall joint is required. See 8.4.4.3 Step Apron.*

*The bottom skins of composite panels have an integral side lap with a re-entrant sealing space which acts as a vapour control, but in high-risk applications such as food processing buildings, textile mills, and indoor swimming pools an additional sealer strip is required at the lining. Concealed fix systems may be used on very low pitches to conceal the fasteners from the weather and keep it out of sight.*

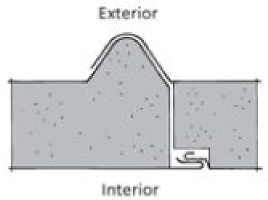
## 15.5.9 Flashings

Flashings detailing is similar to that used with single skin roof and wall cladding or built-up systems, but there are minor differences that may influence design decisions and special requirements that should be addressed.

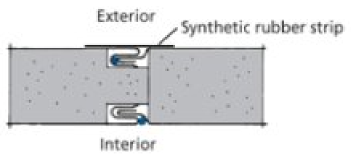
The panels at the ridge should be sealed and the lining closed with a metal trim mounted on the ridge purlins. Any gap between the ends of the composite panels should be insulated to eliminate cold spots or cold bridging. They can be sealed using in-situ injected foam or mineral fibre. In high humidity applications the liner trim should be sealed to the panels, and at end-laps or gaps, foam should be injected to provide a vapour tight seal.

Eaves panels should have the ends turned down to direct water to drip into the gutter, and to have a metal flashing to cover the exposed end of the insulation and metal liner.

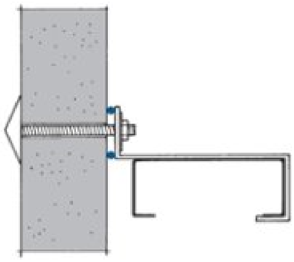
### 15.5.9A Profiled Panel Joint



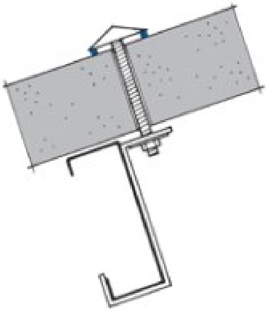

### 15.5.9B Panel Joint



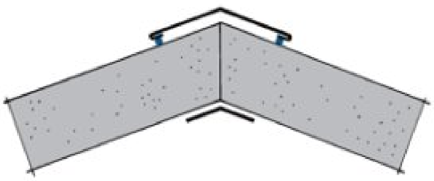
## 15.5.9C Girt Fixing (Internal)



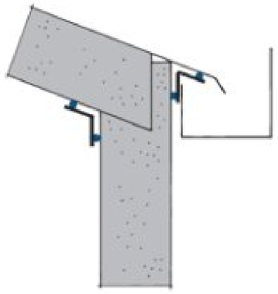
## 15.5.9D Roof–Purlin Fixing



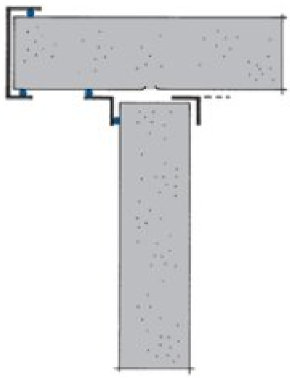
## 15.5.9E Section through Ridge



## 15.5.9F Section through Eave



## 15.5.9G Section through Verge



# 16 Maintenance

Maintenance is defined as 'to keep in good condition or repair', and can be divided into four categories:

- Normal.
- Scheduled or Planned.
- Preventative.
- Special.

## 16.1 Improved Durability

*Most people do maintenance retro-actively, they mow lawns, wash the car or remove debris from gutters when they see it needs to be done. While rain washed metal roof surfaces do not generally require maintenance to comply with warranty conditions, it is always good practice to conduct regular inspections for dirt build up or deteriorating components, which can be removed or replaced respectively before they contaminate the body of the roof. Unwashed areas of roofing and wall cladding do require regular maintenance to comply with warranty conditions.*

*Section B2 – Durability of the NZBC gives live cycle requirements for materials of 5, 15 or 50 years "subject to normal maintenance".*

*In most applications profiled metal cladding and associated materials have a 15 year requirement to comply this clause. Cladding used as structural bracing, and hidden elements, may require 50 year durability, and exposed spouting and downpipes, 5 years.*

*The use of pre-coated or pre-finished roof and wall cladding with a minimum 15-year warranty, has led to the belief that no maintenance is required for that period. That is incorrect. The terms of the warranty state that maintenance is required, and the performance of metal claddings is entirely dependent on the environment. See 4.3 Metal Performance.*

**Individual components of a building system that are difficult to access or replace must either all have the same durability; or must be installed in a manner that permits their replacement without the need to remove building components that have greater durability.**

*In this context, the performance requirements of the NZBC means there should be no moisture penetration due to product failure. That means fasteners still comply with the NZBC as long they prevent water ingress, despite having deteriorated visually.*
*Continued maintenance and over-painting will enhance the decorative appearance and extend the lifespan of all roof and wall cladding, and rainwater products.*

## 16.2 Normal Maintenance

The maintenance described in this section refers to the maintenance of the building envelope; it excludes equipment located on the roof cladding, such as air-conditioning or communications equipment.

Maintenance work and workers must comply with 13.6 Walking On Roofs. Normal maintenance is the work necessary to achieve the claimed or expected product durability. The extent and nature of the maintenance will depend on the material, its position on the building, geographical location and the macro- and micro-environment of the building site.
Section B2—Durability of the NZBC defines 'normal maintenance' as: "work that is generally recognised as being necessary to achieve durability for a given roofing element...."

It is the responsibility of the person specifying the building element to determine normal maintenance requirements. The specifier should select materials taking into account the accessibility of the building element and the practicality of conducting regular maintenance for areas with restricted access.

Normal Maintenance tasks include:

- following manufacturers maintenance recommendations;
- washing down surfaces, particularly exterior building elements, subject to wind driven salt spray;
- re-coating interior and exterior protective finishes; and
- replacing sealant in joints.

Compliance with the durability requirements of the COP should not include replacing protective surfaces on roof and wall cladding, and accessories if the products are selected, installed and maintained in accordance with good practice.

It is the responsibility of the person specifying the building product to determine the normal maintenance requirements for the material.

Because of the natural disinclination to carry out maintenance on parts of the building that is not seen or is higher than 3 m, ' normal' maintenance should become 'scheduled', and will require washing as per the schedule in 16.3 Scheduled Maintenance.

# 16.3 Scheduled Maintenance

Scheduled maintenance is routine maintenance that is performed at regular intervals.

All roofing and cladding products are subject to the cumulative effects of weather, dust and other deposits. Normal rain washing will remove most accumulated atmospheric contaminants, and little maintenance is required on an exposed well designed and installed roof.

All other areas are regarded as 'unwashed areas', i.e., those areas protected from the direct effect of rain. These include all vertical wall surfaces that are above an angled line drawn at 45° to intersect the edge of the overhang or soffit, the underside of gutters or fascias, and the sheltered areas of garage doors. See 4.11.1 Unwashed Areas

**Manual washing is required to prevent the accumulation of dirt, debris or other material not removed by rain. Wall should be washed:**

- **every 6 months in severe environments; and**
- **every 12 months in moderate environments.**

**Areas that do not receive adequate or any rain washing such as soffits, wall cladding under eaves, the underside of gutters, fascias, sheltered areas of garage doors, and unwashed roof areas: should be washed:**

- **every 3 months for severe environments; and**
- **every 6 months for moderate environments.**

*Scheduled maintenance comprises the inspection, maintenance, and reporting procedures for building elements required to have a compliance schedule in terms of section 44 of the Building Act.*
*By following those procedures, the building elements are effectively deemed to have a durability for the life of the building, because they are required to perform as designed at all times. The relevant maintenance procedures may include total replacement.*
*Warranty requirements and durability compliance will only be met if the maintenance requirements specified by the coil coating manufacturer are followed.*

## 16.4 Preventative Maintenance

*Good design can avoid frequent maintenance, but preventative maintenance may provide the most economical solution. This can be achieved by enhancing the product before installation, or by painting metal cladding at nominated intervals.*

Where the underside of metal roof cladding is subject to contaminants such as salt at the gutter line, an over-flashing should be inserted between the roof and the gutter to prevent deposits which lead to 'inside out' corrosion. This flashing can become a sacrificial one where dissimilar metals are used for gutters or spouting, and where splashes and contaminants can corrode the roof cladding. See 8.4.4.4 Eaves Flashing.

Where the gutter line micro-environment is likely to be severe, the underside of metal cladding should be painted using a two pack epoxy primer or elastomeric polyurethane paint before installation.

Building underlay alone can provide this protection if carried down into the gutter, but does not have a 50-year durability if exposed to UV and can give rise to flutter noise if lapped too far into the gutter.

Where roof cladding is exposed to the elements from the underside, it should be included in the maintenance schedule for unwashed areas.

*Seagulls perching on ridgings or parapets on buildings can cause damage from rubbish dropped onto the roof, and from their alkali droppings. Discouraging devices such as wire or spikes can be used to prevent this. Unpainted aluminium or AZ coatings are particularly prone to attack from alkali.*

## 16.5 Special Maintenance

*High-risk areas such as around flues, near fumes from exhaust fans, under television aerials or overhanging trees, sites prone to mould, lichen and bird droppings or debris, all need to have extensive manual washing. Proximity to a motorway can cause the collection of fine dust, as can earthworks in the vicinity, and shavings from wood processing plants are often blown into crevices under flashings which retain moisture and can create 'poultice corrosion'.*

*Bird droppings should be cleared away regularly to avoid premature failure at ridges or bird perches. Canopies above load-out doors have large unwashed areas on their undersides and service station canopies are subject to a harsh environment so they should be treated as a special maintenance cases.*

## 16.6 Inspection

The building owner should be informed of the maintenance required to keep the cladding within the terms of the warranty, and he should be provided with documentary evidence of his obligations. Regular inspection by specialist consultants should be undertaken annually. Records should be kept of all such inspections, which will support any subsequent claims against the manufacturer, supplier or installer. Records will also assist in the process of mediation or arbitration of any such claims.

*Without documentary evidence of regular maintenance, any rectification is solely at the discretion of the supplier. Any subsequent work undertaken on the roof cladding by others that do not comply with this Code of Practice will void any warranty.*

*Inspections and the report s should cover the fixings, gutters, downpipes, flashings and the surface condition of the cladding. The reports should be placed in the 'Building Maintenance Manual', which should contain dated particulars of the original contract, the type of cladding, it's colour and gauge, the warranty, and reference should be made to any leaks reported and repair work or additions carried out. Regular inspection should be regarded as preventative maintenance.*

### 16.6.1 Installation

*Approved fixers of the members of The New Zealand Metal Roofing Manufacturers Inc (NZMRM Inc) and members of the Roofing Association of New Zealand, (RANZ) will provide a warranty for five years to cover the workmanship and installation of the roof and wall cladding if requested. This means that if the standard of workmanship of the roofing contractor does not comply with this NZ Roofing Code of Practice, and he is a member of RANZ, the installation will be renewed or restored so that it does comply.*

*This warranty does not extend to any work undertaken on the roof or wall cladding or accessories by other trades or subsequent to completion of the contract by the roofing contractor.*

*Designers and owners are therefore strongly advised to only deal with members of both of these recognised trade organisations to obtain this warranty.*

## 16.7 Washing

*Regular washing of pre-painted roofing products increases their durability by reducing attack from airborne salts and pollutants. Unpainted products, although not recommended for use in severe or very severe environments, will also benefit from routine washing.*
*Washing may be carried out with a hose and a soft bristle brush, using fresh water. In areas where heavy industrial deposits dull the surface, a thorough cleaning can be ensured by using a 10% solution of household detergent and fresh water followed by a thorough rinse with clean water.*

Stronger concentrations of cleaners than those recommended can damage coating surfaces, and organic solvents and abrasive cleaners should not be used. When cleaning coated surfaces, tar and similar substances may be removed with mineral turpentine, but the surfaces should then be washed thoroughly with detergent and water.

Always clean coated surfaces from top to bottom, and rinse immediately and thoroughly with fresh, clean water avoiding over-cleaning or scrubbing, which can damage painted surfaces.

The scrubbing of bare AZ coated steel cladding can remove the thin factory applied clear acrylic film and should be avoided for this reason.

**High-pressure water blasting must not be used to clean pre-painted metal as it can damage the paint surface and water blasting can also force water into areas that it would not be subject to under normal weathering and thus cause water ingress.**

**If water runoff is used for drinking water, roof outlets must be disconnected before washing any roof or wall cladding using detergents. Care must be taken not to contaminate waterways.**

### 16.7.1 Lichen And Mould

*Some types of local environment are particularly conducive to lichen or mould growth; including areas of wet, dark, or shaded surroundings where trees are in the proximity, overhang roof cladding or low lying valleys where moisture-laden air accumulates as fog or mist.*

*Lichen is a naturally occurring phenomenon with their spores being dispersed by the wind and lichen will grow even on inert materials such as G.R.P. and glass.*

*As lichen and mould retain moisture, their removal is in the best interest of the longevity of metal cladding, but recolonisation is very likely. Mould growth can be removed by washing down the roof or wall cladding, and applying a 2% solution of sodium hypochlorite to all surfaces by low-pressure spray, broom or brush.*

*The surface should be left for 5 minutes but should then be rinsed and thoroughly washed down with cold water. Household bleach contains various concentrations of sodium hypochlorite; therefore, it may be necessary to dilute it.*

*For example:*

- *One brand has 30 g/L solution ( 3% ) – to obtain a 2% solution, 2 parts of bleach should be diluted with 1 part of water. (3 - 2 = 1).*

- *Another brand has 40 grams/L solution (4%) – to obtain a 2% solution, 2 parts of bleach should be diluted with 2 parts of water. (4 - 2 = 2).*
- *Another brand has 50 grams/L solution (5%) – to obtain a 2% solution, 2 parts of bleach should be diluted with 3 parts of water. (5 - 2 = 3).*

*If the roof is used for the collection of drinking water see* 16.10 *Drinking Water.*

## 16.7.2 Graffiti

*Metal wall cladding like most vertical surfaces is subject to being defaced by graffiti. Graffiti removal is likely to affect the pre-painted finishes on metal roof and wall cladding, and before removal is attempted a small area should be cleaned as a trial. Graffiti removers may soften the paint, remove the gloss or may cause permanent damage.* Do not use MEK (methyl ethyl ketone), toluene, acetone or thinners. Overpainting or replacement are the alternative options.

*There are clear removable anti-graffiti coatings available but they are an expensive option and should be compatible with the paint system.*

## 16.8 Overpainting

*To achieve a satisfactory result when overpainting it is vital that preliminary preparation is carried out before painting, and the same cleaning process can be used for new, weathered or prepainted roofs.*

The surface preparation, painting and over-painting of metal roof and wall cladding should be carried out by specialist contractors.

To achieve satisfactory adhesion and optimum results, all dirt should be washed away and cleaning agents such as soap or detergent should be fully washed off the surface prior to paint application. Over-painting a dirty or wet surface results in poor adhesion of the paint and consequently a reduced life; it can also cause premature corrosion of steel cladding.

Thoroughly clean the surface with fresh flowing water and a medium stiff nylon bristle broom or water blast at 20 MPa ( less than 3 000 p.s.i.). When cleaning the profile of any dirt, lichen or mould, care should be taken not to drive water under laps or flashings.

Rinse the profile swages thoroughly, as any remaining dirt will dry and impair subsequent paint adhesion. Particular attention should be given to the drip edge where the final 15 mm is prone to heavy dirt build-up, and to the coating at the front edge of tile profiles as dirt collects in this area and gives rise to mould and algae growth.

Fallout around flues needs to removed before painting.

Allow the roof to dry.

### 16.8.1 Unpainted Cladding

*The practice of leaving metallically coated roof cladding to weather before painting is no longer recommended. With the latest developments in primers, roofs can now be painted immediately after installation, and it should be done within one month.*

For new AZ coated cladding, only acrylic galvanised iron primers should be used, as solvent-based primers may damage the coating. A solvent-borne corrosion resistant galvanised-iron primer should be used for optimum performance on weathered zinc coated cladding over twelve months old.

*After the primer, two coats of acrylic roofing paint should be applied in the selected colour to provide a paint thickness of 50 µm (typically two brush applied coats achieve 50 µm ).*

*If the cladding is weathered but shows signs of white or red corrosion or damage back to the metal base, proceed with painting as described 16.8.3 Weathered With White Corrosion and 16.8.4 Red Corrosion.*

### 16.8.2 Repainting Painted Claddings

*Repainting painted claddings should be regarded as part of the maintenance programme to extend the life of all metal claddings.*

*There is an optimum time at which to repaint claddings, and this decision should be made by the owner after*

*specialist consultation.*
*It is also known as 'the life to first maintenance, ' and is the time before excessive chalking has taken place or the top coat weathered away.*

*Painted products can be readily over-painted with high-quality acrylic roof paints to extend the life of the roof cladding and if over-painting is carried out while the top coat is still in sound condition there is no need to use a primer.*

*To prepare the surface for painting all pre-painted products should have their surfaces abraded with a fine grit sandpaper, stiff nylon bristle broom or similar, to improve the adhesion. Care should be exercised not to sand through the existing paint surface on external bends.*

## 16.8.3
## Weathered With White Corrosion

*If the white corrosion can be easily removed and no red rusting has developed, the roof cladding should be cleaned as outlined above. Neutralise the areas where white corrosion is present with a proprietary metal cleaner designed for this purpose and follow instructions on the container closely. If all residues from the metal cleaner are not removed before painting, poor paint adhesion will result.*

*Painting should take place as soon as possible after this pre-treatment. The presence of white corrosion indicates that the primer has been consumed and so isolated areas of white corrosion should be spot primed once these areas have been cleaned and neutralised. If all external bends are showing corrosion, coat the whole area with an acrylic galvanised iron primer.*

*For unpainted products, it is necessary to use a primer over the whole surface.*

## 16.8.4
## Red Corrosion

*Red corrosion, or corrosion at the edges of the profiled steel cladding should be prepared as follows:*
*Manually de-scale and remove all white and red rust by abrading to bright, firm metal, ensuring that the surface is as smooth as possible. Thoroughly clean the roof as described previously and neutralise the corrosion reaction with a commercially available metal cleaner made for this purpose.*

This type of solution should not be allowed to dry on the surface before fully washing off, and all residues of the metal treatment should be removed prior to painting . Dry all surfaces before spot priming the cleaned bare red corrosion affected areas with a zinc-rich primer .

*Coat the whole prepared areas with a water based galvanised iron primer and apply two topcoats of acrylic roofing paint to the dry, primed area.*

## 16.8.5
## Paint

*High quality, 100% acrylic paint can give a service life of up to 10 years when applied to specification on correctly*

*prepared metal surfaces. This lifespan will vary slightly with colour, roof orientation and the aesthetic requirements of the situation, but poor paint curing will downgrade durability.*
*Paint should not be applied on wet days, when condensation has not completely dried, on cold days below 10° or hot days above 30°. Windy days are also not suitable, as curing is impaired.*

*The painting of very hot roofs will result in the evaporation of the solvent before full film formation can take place, and so will reduce the life of the coating.*

*Ridge ladders should be fitted with protective buffers or rubber pads as they can cause extensive abrasion damage to pre-coated metal cladding. Where it is possible the painter should walk in the pan, but when it is necessary to step on the rib, attention should be paid to sheet overlaps as these may spring up after a painter's weight is removed and reveal an unpainted line.*

*Decking profiles have a tight roll-formed bend at the top of the upstand and care is necessary to ensure the specified film build is applied in this area.*

## 16.8.6
## Brush Application

*The use of nylon brushes is advisable, and these should be wetted with water prior to use to avoid clogging, and in warm weather should be washed out completely at every rest break.*
*Apply two full even coats of acrylic paint to a dry film build of 50 µm, allowing sufficient drying time between coats, but do not over-brush and thin only sparingly.*

## 16.8.7
## Roller Application

*Apply to the spreading rate and film build specified for brush application. Dampen the roller prior to use, then load up the roller and apply two full even coats, allowing sufficient drying time between coats.*
*Apply with even pressure, and do not over-roll. Profiled rollers are available for corrugated profiles, but some profiles may require the combined use of brush and roller of the paint for complete application.*

## 16.8.8
## Spray Application

*Apply to the dry film building specification of a minimum of 50 µm. Airless spray equipment can achieve very high film builds giving rise to runs and uneven coatings. When using spray equipment on hot or windy days, the paint spray may dry before it has reached the metal, which leaves a sandy appearance and feel. This is not aesthetically acceptable and will not provide the even coating required, even though it may measure 50 µm.*
*Do not spray before 10.00 am or after 3.00 pm as condensation can be present. Outside this time space steel will also cool rapidly, which will impair curing and can result in incorrect film formation. It can lead to early failure of the coating. These hours could be extended in mid-summer to before 9.00 am or after 4.00 pm.*

The gloss and weathering characteristics of oven cured and air dried paints are different, and over time a significant difference in colour may become apparent. Variations in natural light conditions will emphasise these differences producing unacceptable aesthetic variations. For this reason, the whole roof area should be painted and not patch painted and this also is the reason why 'touch-up' paint should not be used.

Spray cans should not be used for repairing scratches on pre-painted cladding. Minor surface scratches are best left because they become less noticeable as the coating weathers. If the scratch cannot be seen from the ground, it should be left alone.

## 16.9 Material Selection

*The selection of the most suitable material for metal roof and wall cladding, compliant with the durability requirements of the NZBC, depends on the design of the building and its location or environmental category. Manufacturers offer different metallic and paint coatings and different metals that are suitable for all different environments.*
*Designers are urged to select the material in conjunction with the conditions of any expected warranty before the material is specified. The durability of the material is not necessarily confined to the number of years stated in a warranty and is only indicative of the performance of different substrates and coatings.*

*Those factors that the designer can influence are covered in many other sections of this Code. Cost and colour should not be the major determining factors, and designs using unwashed areas or detailing using different metals requires careful material selection.*

*Any warranty for roof or wall cladding is divided into two parts, the material, and the workmanship. Workmanship warranties are usually provided by the Roofing Contractor for a minimum period of two years; however, this period is extended to five years by Roofing Contractors who are members of RANZ.*

*There is a difference between the warranty offered for residential and commercial use of metal roof and wall cladding.*

*The maintenance of metal roof and wall cladding is very dependent on two factors - design and materials.*

*The preparation of a maintenance manual for owners is an indication to the owner that periodic maintenance is required to comply with the manufacturer's warranty conditions.*

### 16.9.1 Residential

Consumer expectations include appearance in relation to performance, but the NZBC does not. The ease of replacement might satisfy the Building Code, but not always the consumer.

Trade literature is available from the coated steel or pre-painted metal supplier and the product manufacturer which sets out prescriptive design, installation and maintenance instructions that should be adhered to if a warranty is to be upheld.

Although the product manufacturer or the contractor has no control over the maintenance part of these conditions, it is his obligation to inform the owner or his representative of the maintenance requirements specific to the material to comply with the NZBC.

This material warranty is for a minimum of 15 years against perforation unless specifically stated.

### 16.9.2 Commercial

Material selection for commercial and industrial construction may require a different approach if the maintenance can be carried out as tax-deductible expenditure.

Any commercial warranty offered by the coated metal or prepainted metal supplier is specific for the environment and end use, and a request should be made to the supplier before installation as they are only issued upon the satisfactory completion of the contract.

Such warranties are also issued for different types of metal substrate and coatings only on condition that the requirements for their use and maintenance are complied with.

## 16.9.3 Responsibility and Liability

*There is a joint responsibility between all the parties to ensure compliance with the terms of the warranty. The designer, manufacturer, contractor, roofing contractor, and the owner should be made aware of their responsibilities, and all parties are considered to have been informed of their obligation if they have sighted or signed a warranty.*

*If the requirements of the NZBC or consumer legislation knowingly cannot be met, or if the conditions of the warranty or the requirements are knowingly impractical or ignored, the liability remains with those who ignored them. There is an implied warranty requirement within the Building Act that the material selected and used will be suitable for purpose. The material can be used without compliance with the NZBC, but only on a written statement to that effect given by the roofing contractor and with the consent of the T.A.*

16.9.3A Metallically Coated Cladding Endurance and 16.9.3B Naturally Washed Cladding Endurance give an indication of the period that metal roof and wall cladding will not perforate from corrosion in a well-washed situation providing maintenance requirements are met. See 16 Maintenance

In unwashed areas the durability of wall cladding, spouting or flashings are likely to be less than that indicated in the tables.

16.9.3A Metallically Coated Cladding Endurance and 16.9.3B Naturally Washed Cladding Endurance do not necessarily consider the aesthetic appearance of the metal coating or the 'life to first maintenance '. See 16.8.2 Repainting Painted Claddings.

The indication for rainwater goods depends on the environment and the ability of any spouting or gutter to be able to drain and avoid ponding.

The COP strongly recommends an enquiry into the terms and conditions of an expected warranty before finalising material selection and issuing tender documents, as 16.9.3A Metallically Coated Cladding Endurance and 16.9.3B Naturally Washed Cladding Endurance are not warranties.

The range in years provides for differences in each environmental category as described in 4.6 Environmental Categories.

*COP Category B – Moderate Inland.*
*COP Category C – Moderate Marine*

*COP Category D –Severe Marine*
*COP Category E – Very Severe Marine*

*Important: **Check with supplier as materials used in these areas may not satisfy the durability requirements of the NZBC.***
*R/W = Roof and walls*

*RGS = Rain-water Goods*

## 16.9.3A Metallically Coated Cladding Endurance

**INDICATIVE PERFORMANCE IN YEARS THAT NATURALLY WASHED METALLIC COATED STEEL BASED CLADDING WILL NOT PERFORATE FROM CORROSION.**

| Environmental Category | **B/C** | **D** | **E** | **B/C** | **D** | **E** |
|---|---|---|---|---|---|---|
| Coating | R/W | R/W | R/W | RGS | RGS | RGS |
| Galvanised Z450 | 15/30 | • | • | • | • | • |
| AZ 150 | 15/40 | • | • | 10 | • | • |
| Prepainted AZ150 | 30/40 | 15/25 | • | 10/15 | 10 | • |
| Prepainted AZ200 | 30/50 | 20/40 | 15 | 12/15 | 10 | • |

## 16.9.3B Naturally Washed Cladding Endurance

**INDICATIVE PERFORMANCE IN YEARS THAT NATURALLY WASHED METAL CLADDING WILL NOT PERFORATE FROM CORROSION.**

| Environmental Category | **B/C** | **D** | **E** | **B/C** | **D** | **E** | **B/C** | **D** | **E** |
|---|---|---|---|---|---|---|---|---|---|
| Coating | Roof | Roof | Roof | Wall | Wall | Wall | RGS | RGS | RGS |
| Unpainted aluminium | 25/40 | 20/30 | 15/25 | 15/40 | 15/30 | 10/20 | 10 | 10 | 5 |
| Polyester/Acrylic Aluminium | 30/50 | 25/50 | 20/40 | 25/45 | 20/40 | 15/35 | 15 | 15 | 10 |
| PVF2 Aluminium | 35/50 | 30/50 | 25/40 | 30/45 | 25/40 | 20/35 | 15 | 15 | 10 |
| Zinc | >50 | >50 | 50 | >50 | >50 | 50 | 10 | 10 | 10 |
| Copper | >50 | >50 | >50 | >50 | >50 | >50 | >50 | >50 | >50 |
| Stainless steel | >50 | >50 | >50 | >50 | >50 | >50 | >50 | >50 | >50 |

## 16.9.4 Special Environments And Exclusions

- *Maintenance requirements not fulfilled.*

- *Unwashed areas.*
- *Garage Doors.*
- *Damage due to handling, storage, roll-forming and installation.*
- *Design not in accordance with N.Z. Roofing Code of Practice.*
- *Consequential loss.*
- *Accumulation of debris.*
- *Geothermal areas.*
- *Internal environments from fumes or pollutants.*
- *West Coast South Island.*

## 16.10 Drinking Water

*Rainwater collected from roofs clad with steel and prepainted steel products will comply with the provisions of NZBC G 1 2.3.1, provided the water is not contaminated from other sources.*
*The first 25 mm of rainfall from a newly installed roof should be discarded before drinking water collection starts, and always disconnect downpipes when painting a roof. Spouting should be regularly cleaned to avoid the build-up of dirt and debris that can affect water quality.*

*Where a paint or paint system is applied to the roof, its suitability for the collection of drinking water should be established. When rainwater from pre-painted roof cladding is used for drinking, it is advisable to repaint the roof as soon as its surface has weathered.*

*Water collected from metal roof cladding, spouting or gutters made from aluminium, copper and stainless steel will not normally be contaminated by rainfall in suburban and rural areas. However, fallout from manufacturing plants, top dressing, and the contamination resulting from roof cleaning can affect the water quality, and in these cases downpipes should be disconnected.*

## 16.11 Storage

**Roof and wall cladding must be kept dry, covered and protected from damage while stored on the site. When sheets are to be stored on the ground, they must be stacked horizontally on a firm and level surface on top of cross-stacked untreated timber fillets, inclined slightly for rainwater runoff and be covered with a loose tarpaulin allowing air to circulate.**

Sheets should be stacked in sheltered positions preferably near areas of the building where it is to be fixed, and they should be stacked in the order in which they will be used.

The height of such stacks should not exceed 1 m, and they should be clear of the ground. If it is necessary to stack sheets in an exposed position, they should be secured against any movement by the wind.

*Well ventilated storage is essential as rainwater, or condensation in humid weather can penetrate and damage close-stacked metal cladding by capillary action. Always store metal products under cover in clean, well ventilated buildings.*
*Once packs are opened and laying of the roof or wall cladding commences, a continual visual check should be made to ensure the surface of the sheets are free of any noticeable defect or damage. This is particularly important with pre-coated materials.*

# 17 Testing

Section 15 sets out the design and performance requirements for sheet roof and wall cladding systems specifically for New Zealand. While it is intended that only those people associated with testing would be concerned with the details of the test procedures it is of general and historical interest as to the reasoning behind the performance requirements.

For this reason a commentary is provided which follows each part.

Section 15 is divided into general requirements and specific methods of testing sheet roof and wall cladding for point load and also to determine their resistance to wind pressures. (UDL - uniformly distributed load).

These procedures apply to all metals and plastic sheeting however because of their different characteristics some of the performance criteria are different.

## 17.1 Scope

*To demonstrate the compliance with this Code of Practice, roof and wall cladding systems must be tested in accordance with this section in the MRM COP.*

### 17.1.1 Allowance for variability of materials

*Provision is made in 17.1.1A Variability Factors for the testing of more than one sample of a test specimen to allow for variability of materials. If many tests are carried out, each sample is required to satisfy the performance criteria.*
*Where various tests are conducted on pierce-fixed roofs at different span lengths, using the same profile, type, and thickness of cladding, fastening type and pattern, and they have the same mode of failure, they must be included as complying with the number of units in 17.1.1A Variability Factors.*
*Where only static testing is conducted and cyclic test verification testing is not used, the variability factors must be strictly in accordance with 17.1.1A Variability Factors.*

*The design capacity ($R_d$) must satisfy*

$R_d < R_{min} / k_t$ *where* $R_{min}$ *is the minimum test value and the factor* $k_t$ *is given in 17.1.1A Variability Factors.*

#### 17.1.1A Variability Factors

| No units to be tested | Coefficient of variation | | | |
|---|---|---|---|---|
| | 5% | 10% | 15% | 20% |
| 1 | 1.20 | 1.46 | 1.79 | 2.21 |
| 2 | 1.17 | 1.38 | 1.64 | 1.96 |
| 3 | 1.15 | 1.33 | 1.56 | 1.83 |
| 4 | 1.15 | 1.30 | 1.50 | 1.74 |
| 5 | 1.13 | 1.28 | 1.46 | 1.67 |
| 10 | 1.10 | 1.21 | 1.34 | 1.49 |

*Factor(kt) to allow for variability of structural units.*

*NOTE: For values between those listed in the table interpolation may be used.*

*It is recommended that the Coefficient of variation is established by using the standard deviation method.*

### 17.1.2 Resistance to point load

## 17.1.2A General

The point load requirements of this section of this standard classify roof and wall cladding as:

*Type 1: Areas that can be accessed from opening windows or awnings. This classification is intended to allow for people gathering to watch a parade or similar situations.*
*Type 2: Areas that require access for maintenance purposes. Type 2 is for all other roofs that are readily accessible and it divided into two categories.*

- *Type A is unrestricted access, where a person may walk anywhere on the roof cladding.*
- *Type B is restricted access, where access is restricted to walking within 300 mm of the purlin line or in the pan of the profile.*

*Type 3: Areas for which support ladders or boards are required for maintenance access (including transparent surfaces) 0.5 kN.*

*Type 3, No Access' Roofs that are not readily accessible which include, plastic sheeting, roof surfaces with a pitch of more than 35°, or that are regarded as unsafe or unable to be walked or worked on without special provisions being made. Walls are included in this category.*

## 17.1.2B Seviceability Test

When subjected to a point test load as prescribed in this section none of the following must occur :

- Permanent local deformation (except within residual deflection limits).
- De-indexing or unclipping.
- Fracture or failure of any part of the cladding.
- Fastener failure.

The residual deflection under the point of application of the load within a minimum of 1 minute after removal of the load must not exceed S/400.

For Type A access the concentrated load must be applied to those parts of the cladding which will produce maximum deflection and maximum permanent deformation.

For Type B access the concentrated load must be applied to the pan of the profile at mid-span or any part of the cladding within 300 mm of the purlin line. Where the pan of the profile is less than 100 mm wide, any point load must be spread over two or more ribs.

## 17.1.2C Strenth Test

When any part of the cladding for Type 2A & B, is subjected for not less than 1 minute to a concentrated test load for strength limit state in accordance with 17.5 Wind load Span Graphs, the load must be sustained, irrespective of any permanent deformation that may occur.
*Where it is intended to conduct a series of tests, the point load is determined by multiplying the load given in 17.1.2A General by the factor in the 5% variability column of 17.1.1A Variability Factors.*

## 17.1.3
## Resistance for wind pressures

### 17.1.3A Serviceability Test

When the cladding system is subjected to the Uniformly Distributed Load (UDL) test load as prescribed in 17.7 Wind and Point Load Testing none of the following must occur:

Permanent local deformation (except within residual deflection limits).

De-indexing or unclipping.

Fracture or failure of any part of the cladding.

Fastener Failure.

### 17.1.3B Strength Test

When the cladding system is subjected to the test pressure for strength limit state (as specified in Wind and Point Load Testing), the pressure must be sustained, notwithstanding any permanent distortion that might occur in the sheeting and fastenings.

Type A:
Unrestricted access, where a person may walk anywhere on the roof cladding.

Type B:
Restricted access, where access is restricted to walking within 300 mm of the purlin line or in the pan of the profile.

Type 3:
Areas for which support ladders or boards are required for maintenance access (including transparent surfaces) 0.5 kN.

Type 3, no Access':
Roofs that are not readily accessible which include plastic sheeting, roof surfaces with a pitch of more than 35°; or that are regarded as unsafe or unable to be walked or worked on without special provisions being made. Walls are included in this category.

# 17.2 Commentary On Part 16.1

### C1.1. GENERAL

*Historically there has not been a specific New Zealand based Standard for testing sheet roof and wall cladding, so that most testing has been carried out using requirements and methods based on the Australian Standards AS 1562 and AS 4040. These two standards are closely interrelated as AS 1562 sets out the performance requirements while AS 4040 sets out the test methodology.*
*Although both of these standards have been the subject of a review by a joint Australian New Zealand standards committee for many years, major differences stemming from the respective National Building Codes as well as climatic conditions have been difficult to resolve. While the adoption of the joint Loadings Code AS/NZS1170 Structural design actions, has resolved many of the issues relating to the determination of wind forces on buildings, this has not assisted progress in adopting agreed testing methods and performance benchmarks. For these reasons, this New Zealand test procedure has been adopted by the NZMRM.*

### C.1.2. ALLOWANCE FOR VARIABILITY OF MATERIALS

*Extensive testing has been carried out in New Zealand over many years, but for economic reasons, only a single test has generally been carried out on a specific area of the roof profile for each span, material thickness, grade, and fastening pattern. Where replication of tests has been carried out, the variability due to materials has been negligible. Concentrated load results are very consistent as are those from top fixed steel roof and wall cladding and from the results of hundreds of previous tests the Coefficient of Variation (COV) can be assumed to be taken as less than 5%.*
*The same cannot be said for self-supporting and fully supported secret-fixed roof and wall cladding as the variability occurs from small but significant differences in profile or clip tolerances. It is necessary therefore to establish a variability factor from 17.1.1A Variability Factors that is acceptable for the metal and profile.*

*The assumption that where the mode of failure is the same but at varying structure spacings, the number of tests can be agglomerated, is taken from Australian practice. While this is permissible for pierce fixed roof cladding because of the greater variability of clip fixed roofs these results cannot be treated in the same manner.*

*Extensive testing both static and cyclic on standard profiles with varying fastening patterns have validated the variability values given in 17.1.1A Variability Factors. The use of static testing alone means that the 1.2 factor must be used, not the 1.15 factor provided for in 17.1.1A Variability Factors.*

*The factors in 17.1.1A Variability Factors are the same as those found in AS/NZS 1170 and AS/NZS 4600.*

### C.1.3. RESISTANCE TO CONCENTRATED LOAD

*The requirements and general descriptions are taken from AS/NZS 1170.*

*The division of Type 2 is taken from the NZMRM Code of Practice.*

### C1.3.1.

*The residual deformation criterion of L/400 has been set to allow for the use of different metals and plastic for roof and wall cladding. This is a limiting factor because permanent deformation is an indicator of potential stress failure and is also likely to cause ponding and visual distortion.*

### C.1.3.2.

*Because the concentrated load is known and the number of tests is predetermined, it is possible to factorise the test load from 17.1.1A Variability Factors, unlike a UDL test where the test load in unknown and the results are factorised. Multiple concentrated load tests can be carried out on the same sheet provided that there is nil influence of any failure from a previous test.*

**C.1.4 RESISTANCE TO WIND PRESSURES**

*AS/NZS 1170.0:2002 defines Serviceability as Ability of a structure or structural element to perform adequately for normal use under all expected actions*

*The main function of a roof or wall is to provide a durable weathertight membrane and, therefore, serviceability is the ability to continue to provide a weathertight seal where the fixings penetrate through the cladding under maximum design load. For a Uniformly Distributed Load, this requires finding the applied load under which sufficient permanent deformation occurs that may cause loss of a weather seal at a fixing location. This is regarded as a serviceability failure.*

*Any buckling from point load that impairs the ability of the profile to be able to carry the same repeated load is also regarded as a serviceability failure.*

*From these definitions of serviceability for roof and wall cladding serviceability failure is considered the most important performance criterion, rather than Ultimate failure where the roof would blow off or a person would fall through it. Testing of pierce fastened profiled metal roofs has determined that failure under serviceability loads occurs at less than half the load at which strength load failure occurs. Hence serviceability load failure is considered the most important criterion for such roofs.*

# 17.3 General Methods Of Testing Sheet Roof And Wall Cladding

## 1. REFERENCE DOCUMENTS

*AS/NZS 4040.1 Resistance to concentrated loads*

## 2. TEST METHODS

*The serviceability load test is intended to determine the maximum load at which the cladding and its fastenings would cause permanent deformation where the roof cladding would leak or when replicate test loads could not be sustained.*
*The ultimate-load test is intended to assess the maximum load at which the cladding and its fastenings would not blow off, or a person would not fall through the roof.*

## 3. SUPPORTING STRUCTURE AND EQUIPMENT

*The design of the support system must consist of a rigid frame airbox, sealed on the bottom and four sides. For UDL testing a pressure fan or blower is required, capable of controlling and maintaining the required test pressure using computer software; for Cyclic Load testing the speed and number of cycles must also be computer controlled. The deflection is measured through a differential displacement transducer and traced and recorded coincidentally with the increasing load.*
*N.B. This is a pressure test from beneath the sheeting to simulate a negative load from above.*

*For point load testing, a hydraulic cylinder and calibrated load cell is contained within a moveable rigid yoke attached to the main airbox frame, providing universal access to all parts of the supporting structure.*

*The force measured by the load cell using either a separate digital display or forming part of a computer-based data system must be able to provide an accurate indication of the applied load.*

*The deflection during the load application must be monitored through a differential displacement transducer and indicator, to enable the recording of the deflection at maximum load, and the residual deflection after load removal.*

*The structure must not provide any constraint or longitudinal support (e.g., purlin braces) that will prevent membrane action in the cladding under UDL loading.*

## 4. TEST SPECIMEN

*4.1 Resistance to concentrated loads and wind pressures must be determined by tests of full-scale models of sections of the system as they are intended to be installed.*
*A cladding system must consist of sheeting, fastenings and supporting members assembled in a manner identical within those parts of the particular roof or wall of which the test specimen is intended to be a model.*

*4.2 Width of specimen. The width of a model or the test section of a lapped system must be the width represented by at least two sheet laps. For cladding systems in which the interlocking of the edges of adjoining sheets is essential to their fastening, at least two sheet interlocks must be incorporated in the test specimen.*

*4.3 Number of spans. For testing the resistance of a roof to concentrated loads, and for testing resistance of continuous cladding to wind pressures, the test specimen must incorporate no fewer than four spans, i.e., two end and two intermediate spans.*

*4.4. The ratio of the end span to intermediate span must be between 0.6 and 0.7.*

**5. INTERPRETATION OF RESULTS**

**5.1 Derivation of design data.**

*When using data from testing for the production of graphs, tables or other design aids, the following conditions apply:*
*(a)*

*Data must not be extrapolated except where a minimum of four span combinations within the limitations of (b) below can be shown to provide a statistically* reliable load span graph. In such cases, an extrapolation of a further ±20% at either end may be calculated.*
** Refer commentary re statistical reliability*

*(b)*
*Interpolation of data between different spans of a specific type of test is acceptable only in the following circumstances:*
*(i) Where the data is taken from tests for a single type, size, and profile of cladding and type and spacing of fastener.*
*(ii) Where at least three different spans or support spacings have been tested for the same type, size, and profile of cladding and fastener details and that in all three tests the failure mode was the same.*
*(iii) Where test loads were derived from the same test criteria.*
*Serviceability limit state failure modes that are classified as different are:*

- *permanent deformation around the fastener head that would compromise weatherproofness;*
- *excessive residual deflection from point load or the onset of any de-indexing;*
- *unclipping; or*
- *fracture of the cladding or its fixings.*

*Common strength limit state failure modes which are classified as different include cladding pulling over the fasteners, clips disengaging, de-indexing of sheet interlocks or fasteners pulling from the supporting member.*

*The Variability factors must be those contained in 17.1.1A Variability Factors and must be applied to both the UDL and point load test results.*

## 17.4 Commentary On 16.3

**C4.1.**

*It is not valid to interpolate results from tests that are not identical except as exempted in 5.1. Any change in fastening pattern or substrate or differing end/ intermediate span ratios can have a marked effect on the result. Likewise, the practice of making the insertion of every screw 'perfect' for test purposes is an invalid practice because this does not happen in real life. Overdriving of screws, off-centring or driving a fastener that is not at right angles to the sheeting can make a significant difference to the failure load.*

**C4.3.**

*As the purpose of the tests is to determine the effects of the wind uplift pressure or a point load, it is essential that the arrangement of intermediate and end spans of the test specimen will provide similar results to that encountered by the actual building installation. A single span or even a two span test arrangement will not accurately simulate the reaction forces and bending moments at the purlin fastening positions, with a consequence that the actual real-world performance cannot be accurately determined or interpolated.*
*Calculation of performance is considered invalid because it assumes the section properties remain static under load.*

*Although in the past much of the testing of N.Z. roof and wall cladding has been done with a three equal span arrangement, it evidenced awareness that end spans should be approximately 2/3 of intermediate spans, which means that a three span test which consists of two end spans has no true intermediate span. Because the reaction forces are not the same it is not possible to test a true intermediate span without using a four span test arrangement.*

*A further complicating factor in the determination of performance loads is the use of varying or different fixing patterns. Many pierce-fixed roof cladding profiles are not fixed on every rib which gives rise to variability in the serviceability results, depending whether the fixings on the missed ribs are co-linear or staggered.*

*When using a four span test configuration, there is only one fully loaded central purlin. If the penultimate purlins have a staggered fixing pattern in relation to the central purlin, the rib that is fastened at the central purlin will fail at approximately 10 -15% less load than had the fastening pattern be fully linear. Linear fastening is where the same rib is fastened at each purlin and the adjoining ribs are not fixed, except at the ends. Where a staggered fixing pattern is to be tested a minimum of five spans must be used.*

**C4.4.**

*The end span is reduced to approximately 66% of the intermediate span because at one end it is simply supported. This proportion coincidentally approximates the increase in the peripheral wind load at the proximity of the end spans and is also often the area that suffers the highest point loads caused by people accessing the roof structure.*

**C5.1.**

*A plot of log P v log L has straight line fit with R2 better than 0.95 will provide a means of determining that the extrapolation is statistically reliable.*
*The most common serviceability limit state failure mode is permanent local deformation, which commonly precedes fracture or buckling.*

*Current research indicates that small changes in load can significantly affect the fatigue performance of the cladding.*

# 17.5 Wind load Span Graphs

3.16.5 Wind Load Span Graphs are determined by tests to criteria set out in current Standards or some accepted criteria that are derived from them, and some interpretation of the test results is necessary to fairly evaluate the capability of the product and system being tested. The wind load static tests are intended to simulate actual loads and to simulate wind uplift conditions, whereas cyclic loading would more fairly represent the conditions likely to be experienced over the life of the roof.

Although a number of tests would give the testing authority or manufacturer confidence and a feel for his product, because of cost, usually only one test per permutation is conducted requiring the use of a statistical reduction factor. Statistical methods and the analysis of variance are used to provide data to base manufacturers' performance claims. The results are usually conservative and known rare roof failures have either not followed manufacturers' recommendations or the good trade practice described in this Code of Practice.

Wind Load span graphs can be misleading unless they are well presented and qualified by the method used to obtain them. For pierce fastened profiles, the load should be presented in kPa as a serviceability design load.

The 3.16.5 Wind Load Span Graphs represent a conservative value at which all profiles manufactured in New Zealand within the specifications noted will comply with the NZBC.

# 17.6 Specific Methods Of Testing Sheet Roof And Wall Cladding

**METHOD: RESISTANCE TO POINT (CONCENTRATED) LOADS**

**1. SCOPE**

*This Section sets out a test method for determining the resistance of sheet roof and wall cladding to point (concentrated) loads.*

**2. REFERENCED DOCUMENTS**

*The following documents are referred to in this part:*

- *AS/NZS 1170 Minimum design loads on structures.*
- *AS/NZS 1170.1 Part 1: Dead and live loads and load combinations.*

**3. SUPPORTING STRUCTURE**

*The supporting structure must be as specified in 17.3 General Methods Of Testing Sheet Roof And Wall Cladding.*

**4. LOADING SYSTEM**

Concentrated load:

- *Concentrated load must be applied in a direction normal to the roof through a circular loading pad of rubber or similar material 100 ±2 mm diameter and 50 ±2 mm in thickness. The loading pad must have a Shore durometer hardness of 30 ±3.*
- *The force must be transmitted to the rubber pad through a disc of steel, 100 ±2 mm in diameter and not less than 10 mm in thickness.*
- *Where the dimension of the sheeting profile does not allow the use of a 100 ±2 mm diameter pad the shape must be spread over two ribs and not >0.01m² in area nor exceeding 200 mm in length.*

*NOTE: The 50 mm thickness of rubber may be made up of an appropriate number of layers 10 mm or greater thickness.*

*Measuring devices:*
*Deflections must be determined by means of a device capable of measuring to an accuracy of within ±0.05 mm.*
*Pressures or loads must be determined to an accuracy of within ±2%.*

**5. TEST SPECIMEN**

*The test specimen must be as specified in 17.3 General Methods Of Testing Sheet Roof And Wall Cladding.*

**6. PROCEDURE**

1. *Loads*
   *The loads and Variability factors must be those contained in 17.1.1A Variability Factors.*
   *To determine design loads (target load) for test purposes, the concentrated loads must be those contained in 17.1.2 Resistance to point load. The position of the test load must be determined by the type of test as prescribed in 17.3 General Methods Of Testing Sheet Roof And Wall Cladding.*
   *The target load must be increased by the variability factor determined by the number of tests according to 17.1.1A Variability Factors.*
2. *A preload of 50% of the calculated maximum load must be applied for a period of 1 minute, before removing the load and zeroing the displacement transducer.*

3. *A preload of 50% of the calculated maximum load must be applied for a period of 1 minute, before removing the load and zeroing the displacement transducer.*

***Measurements during serviceability tests.***

*Displacements of the test panel must be measured at a point on the specimen as close as practical to the load application.*

*If failure from buckling or other load discontinuity is evident prior to reaching the required load, the maximum force at failure must be recorded.*

*After not more than 1 minute following the removal of the load the residual displacement of the test panel adjacent to the load application pad must be recorded.*

***Strength limit state.***

*The part of the cladding furthest removed from the substructure and from the supporting members must be subjected to the specified concentrated load for a period of not less than 1 minute, applied to those parts of the cladding which will produce maximum deflection and maximum permanent deformation.*

*The behaviour of cladding, fastenings, supporting members and substructure must be observed and recorded. The maximum load is that which can be sustained irrespective of any permanent deformation.*

**7. REPORT**

*The following information must be supplied in the report:>*

a. *The number of the report and the name of the client.*
b. *The date and location of the test.*
c. *The name of the testing officer.*
d. *The type of test – Serviceability/ Ultimate.*
e. *The test Procedure -reference to this section of the Code of Practice.*
f. *Details of the material under test – Type/Profile/ Material/ thickness/ Spans.*
g. *Substructure.*
h. *Fastener type and fixing pattern.*
i. *Mode and point of failure – Permanent deformation at fastener, mid span buckling.*
j. *Deflection under maximum serviceability load.*
k. *Residual deflection.*

## 17.7 Wind and Point Load Testing

*Profiled steel metal cladding is manufactured from high-strength and low-strength steel. Non-ferrous claddings are classified as low-strength.*
*High-strength steel is the predominant material used for roof cladding in NZ. When roof sheeting is made from low strength steels, deflection under load is more important; it can yield progressively or is deformed by constant traffic, which in turn lowers its performance.*

*Metal roof tiles are usually made from low strength steels and are not intended for roof traffic. (see section 10 roof tiles) .*

Wind and traffic imposed loads are dynamic, moving or fluctuating loads, but most test regimes are static load tests.

The Loadings Code (AS/NZS 1170) requirements consist of serviceability loads and ultimate loads. However, serviceability loads are more relevant to roof cladding because:

- *Any permanent deformation of the ribs of profiled metal cladding – caused by metal expansion or repeated walking, or deformation at the fasteners – will eventually lead to leakage or failure.*
- *Ultimate failure due to a point load on any metal cladding profiles manufactured in NZ has not been known to happen unless corrosion has affected the profile's structural integrity.*
- *The UDL at which ultimate failure would occur on all metal cladding profiles manufactured in New Zealand is caused by structural failure or unsuitable fasteners, not of the material under test.*
- *In the context of testing metal cladding, serviceability loads determine weather resistance. The publishing of strength criteria is irrelevant to pierce fastened profiles. Strength criteria are, however, the determining factors in clip fastened profiles.*

*The citing of AS/NZS 1170 in the NZ Building Code meant that a reassessment of the testing load parameters was necessary. Test ing methods had been under review for a considerable time, and the joint AS/NZS committee made considerable progress in reassessing a cyclic test regime, suitable to New Zealand's climate, to be used as a verification for static UDL loads.*

*During the testing using the new criteria, it became evident that in assessing roof and wall cladding performance a much greater emphasis should be given to the fastening pattern.*

*The effective area of the profile affected by one fastener is known as the 'tributary area'.*

*This means that, although the previous calculations for this parameter have been confirmed, all load/span graphs should be qualified by the fastener type and pattern.*

*The full text of the new regime, including the performance and test requirements, is contained in 17 Testing in this document.*

### 17.7.1 Commentary On Section 15.5

**C6.2.**

*The reason for the required 50% load is that it is used as a 'preload' which settles the sheeting to a stable position before proceeding with the test.*

**C6.3.**

*It is suggested that the increments be at 10% intervals.*

**C6.4.**

*Although deflection under load is not regarded as a design criterion, it is an important indicator of stress leading to permanent strain.*
*Residual deflection, after all load has been removed is regarded as the only deflection criterion that will affect the performance of the sheeting.*

# 17.8 Method: Resistance To Wind Pressures For New Zealand

### 1. SCOPE

*This section sets out a test method for determining the resistance of sheet roof and wall cladding to wind pressures in New Zealand. (UDL)*

### 2. REFERENCED DOCUMENTS

*The following documents are referred to in this part of this Standard:*

- *AS/NZS 1170 Minimum design loads on structures*
- *AS/NZS 1170.2 Part 2: Wind loads*

### 3. SUPPORTING STRUCTURE

*The supporting structure must be as specified in section 15.3.*

### 4. LOADING SYSTEM

1. *The test system used for UDL testing consists of two parts.*
    - *Part A Static Uplift Pressure Test: A sequential static uplift pressure is applied to the cladding assembly with pressure increments based on the fractional proportions, as specified in 6.2., to determine the maximum sustainable pressure before permanent deformation occurs. Pressure is returned to zero after each pressure increment to allow assessment of the onset of permanent deformation.*
    - *Part B Cyclic Uplift Pressure Test; The test is replicated on an identical cladding assembly with a series of cyclical pressure loadings, with pressure increments based on the fractional proportions, as specified in 6.2., of the factored pressure obtained during the static uplift test. The cyclic regime and number of cycles are specified in 6.4.*

    *Where failure due to cracking or other permanent damage from the repeated cyclic loading (Part B) occurs at a lesser pressure than that obtained from the factored Part A static pressure test, the cyclic pressure increment prior to the incidence of failure must be substituted as the performance load.*
2. *The required cyclic wind pressure must be applied by an air box method that will provide a uniform distribution of uplift pressure appropriate to the part of the cladding being tested and maintain such distribution irrespective of the extent of deflection.*
3. *A calibrated manometer must be used to monitor the applied air pressure and ensure the accuracy of the applied air pressure as measured by a transducer. Pressures must be determined to an accuracy of not less than ±2%.*
4. *The cycling rate must be between 1 Hertz and 0.3Hertz (approximately 1-3 seconds).*
5. *Where the measurement of the deflection of a cladding under load is required, measurement must be made with calibrated displacement transducers, measuring to an accuracy of not less than ±0.05 mm. Where such measurement is taken it must be by a three-point arrangement, to allow for movement of the ends of the span being measured.*

### 5.TEST SPECIMEN

*The test specimen must be as specified in section 15.3.*

### 6. LOADING PROCEDURE

*6.1.*

*To determine the static and cyclic target load for Uniformly Distributed load tests the Target loads (TL) must be those determined by:*
*the type of the material*
*the thickness of the material*
*the size of the fastener head or washer (if pierce fixed)*
*the maximum tributary area*
*For pierce fixed cladding the Tributary Area (TA) of a fastener must be determined by half the sum of the spacings between three adjacent fasteners*, multiplied by the sum of the distances between adjacent supports.*

** NB these distances will not always be identical.*

*6.2.*
*The Static test load must be applied incrementally, held for a minimum of one minute and the pressure released to zero. Where a target load has been established the Static Test loads must be applied incrementally to the target load and zeroed after each cycle.*
*i.e.*

*1 @ 80% of the target load*
*1 @ 90% of the target load*
*1 @ 100% of the target load*
*Where a target load has not been established or where it has been exceeded the Static Test loads must be applied in conservative increments based on visual assessment under load.*

*A visual inspection must be made after the load has been removed to determine if permanent deformation has occurred. Where Load spreading washers are used these must be removed to determine if permanent deformation has occurred.*

*At the conclusion of each pressure increment, if there is no visible permanent deformation, the static test must be continued until permanent deformation is observed. The last test pressure to be applied prior to the cladding being assessed as having visible or measurable permanent deformation must be considered the passing static test pressure* ($P_s$)

*6.3.*
*Where multiple tests are conducted at alternative spans and replication is attained as prescribed in section 15.1 (1.2), the Cyclic Load does not need to be applied to each of the cladding test configurations. In this instance, the cyclic test must be applied to only one of these tests and because it is a verification test the result is not required to be factored.*
*6.4.*
*Each cyclic test must consist of a series of sets, each containing 1000 cycles with the pressure within each cycle varying from not more than 50% to 100% of the test load pressure. At the completion of each 1000 cycle set and after all loading has been removed a visual inspection must determine if permanent deformation has occurred. Where Load spreading washers are used these must be removed to determine if permanent deformation or cracking has occurred. If there is no visible or measurable permanent deformation the next cycle must be commenced.*
*The maximum cycle pressure of the initial set of cyclic loading must be 80% of Ps as determined from 6.2, with subsequent sets being incremented by 10%*

*i.e.*

*1000 cycles at 80% of $P_s$, cycling from 40% -80% $P_s$*
*1000 cycles at 90% of $P_s$, cycling from 45% -90% $P_s$*
*1000 cycles at 100% of $P_s$, cycling from 50% - 100% $P_s$*
*Any observed initial onset of cracking or permanent deformation together with the presence of audible sound from the mechanical stress reversals of cladding materials must be recorded for each set.*

*N.B. $P_s$ may be substituted by TL as determined in 6.1.*

*6.5.*
*Serviceability limit state. The model must be subjected to the static and cyclic loads as prescribed in 6.2. and 6.4. Failure is deemed to have occurred when permanent deformation or cracking is visible around the fastener. Where cracking or permanent deformation occurs during a cyclic pressure test set at a pressure below the factored passing static test pressure Ps, this must be deemed the failure load. All static test results for that particular cladding and fastening arrangement must be multiplied by the same factor Pcy /Psf , - P min being the lowest value of the undamaged cyclic pressure sets. Roof and Wall cladding that is clip fixed is deemed to have failed if any of the performance criteria in section 15.1. (1.4.1). has occurred.*

*6.6.*
*Strength limit state. The model must be subjected to the specified static pressures for a period of not less than 1 minute. The behaviour of cladding, fastenings, supporting members and substructure must be observed and recorded. The maximum load is that which can be sustained irrespective of any permanent deformation.*
*N.B. There is no requirement for a cyclic test for strength limit state.*

**7. REPORT**

*The following information must be reported:*

a. *The number of the report and the name of the client.*
b. *The date and location of the test.*
c. *The name of the testing officer.*
d. *The type of test - UDL/ Cyclic / Serviceability/ Ultimate*
e. *The test Procedure.*
f. *Details of the material under test – Type/Profile/ Material/ thickness/ Spans.*
g. *Substructure.*
h. *Fastener type and fixing pattern*
i. *Mode and point of failure- Permanent deformation at fastener, midspan buckling, pull-over,*
j. *Pull-out, cracking.*
k. *Deflection under load (if measured).*
l. *Residual deflection (if measured).*

## 17.9 Commentary On Section 16.6

**C1.**

*It is well known and accepted that New Zealand suffers from frequent and numerous gales, which sometimes approach the wind speed of the cyclonic areas of Australia and the Pacific Islands. This situation has been assisted by the publication of AS/NZS 1170, which places the emphasis on specific location rather than wind speed, and factorising a basic speed dependent on terrain and topography.*
*Wind is a dynamic force and the method of testing sheet roof and wall cladding solely by a static load is not logical. Any test procedure should as closely as possible resemble the loading conditions likely to be experienced by the cladding in the field during its lifetime. This anomaly has come about historically because it was expedient to do so and the cost of cyclic testing, as the alternative to static testing, was considered to be unjustifiable. The validity of static testing results is questioned, particularly when cyclic testing of roof and wall cladding has shown that fatiguing can occur at load level much lower than the static test results. This is particularly true of high strength steel, which has been and continues to be a common material used for domestic and industrial roofs in New Zealand.*

*For these reasons the New Zealand Roofing Industry has established a cyclic regime suitable for verifying the static testing of roof and wall cladding in New Zealand. Factoring static test loads alone has been considered and discarded as being inaccurate and invalid.*

*Results from many tests using high strength steel points to a value at which no damage will occur even up to 10,000 cycles but a small increase in value will quickly initiate crack propagation within a 1000 cycles. It is for this reason that cyclic tests have been increased incrementally. Once the target load has been passed successfully the test can be continued incrementally until failure.*

*The point at which permanent deformation occurs in HS Steel is very close in value to the point when cracking will be initiated and eventually fail over a prolonged cyclic regime. Because of the consistency of test results obtained, there appears to be no justification to test to 10,000 cycles as required in other cyclic test regimes. The use of cyclic testing is intended to be used as a check for the static test as the frequency of cyclic test checking can be adjusted for the material. i.e. low-strength steels are unlikely to suffer fatiguing at their lower levels of performance.*

*The importance of cyclic testing is to provide a performance value for the area of cladding serviced by a single fastener, (the Tributary Area) below which fatiguing is unlikely to occur. Once crack initiation has begun it is inevitable that failure will occur under repeated load.*

*The fastening pattern is a major determining factor where failure due to fatigue is determined not only by the number of fasteners per m2, but also by the washer size as can be seen by the greatly increased performance when using load spreading washers.*

*Any failure is likely to be subjective, as it is with the static test, but any visible cracking or permanent deformation around the fastener in position is deemed to be failure. This means that both the static and the cyclic tests can never be fully automated and will require a physical examination and assessment.*

*Because this standard is material non-specific, it requires subjective judgment as to (say) if the fibreglass reinforcement of GRP sheeting has been permanently deformed.*

*Where clipped sheeting (secret-fix) is used the design value for the tributary area can be a lesser value than for pierce fixed sheeting. Because this value is dependent on the profile shape and clip design, the tributary value leading to the target load, must be established for each profile.*

*It is common practice in NZ to use plastic sheeting in conjunction with metal sheeting at the same purlin spacings. For this reason plastic sheeting should also be included in any test programme.*

**C6.1.**

*The tributary load (TL) is calculated by multiplying the area serviced by the fastener by the test load in kPa. Because fastening patterns are not always symmetrical the maximum mean distance between fasteners is used.*
*Some TL values have been given in the NZMRM Code of Practice for specific thicknesses, profiles of steel, with and without using load spreading washers. Recent tests have confirmed these values however different thicknesses, grades of material and different thicknesses, grades of material, metal and shapes of load spreading washers will give very different results. For this reason their TL values must be established by the method prescribed.*
*All static tests must be subject to checking that the tributary area of the purlin spacing and the fastening spacing fit within the 'no cracking' criteria established and verified by cyclic loading.*

**C6.2.**

*The static test load is applied incrementally to provide opportunity for the observation of the performance of the profile under load. A 'feel' for this performance is easily obtained after conducting a number of tests and these can be used as a practical learning tool for roofers in training.*
*The use of load spreading washers has a major bearing on the performance of sheeting under negative loading which is mainly due to the increased area over which the load is shared. The most commonly used screw fasteners used in NZ are 12# & 14# fasteners and both sizes of Type 17 for timber and self-drilling for steel, have the same screw head diameter. This means that there is no advantage in using a larger screw for 'pull-over'. The load spreading washer as manufactured in New Zealand follows the profile of the sheeting and provides an increase in profile performance of up to 100% as well as providing a seal for the fastener. Because the increase of load of up to this amount applies at the periphery of a building, by using load spreading washers, the additional load can be taken by the sheeting without changing the purlin spacing or fastener frequencies.*

*Calculation does not take into account the changing section properties of the profiled sheeting with increasing load and nor can it allow for the interaction and support provided by adjacent spans. These are very much related to profile and the proportionate relationship with the end and intermediate span.*

**C6.3.**

*The minimum number of sequential tests to provide information for a load/span graph is three. It is suggested that a cyclic test be conducted on one of each of these series per permutation. i.e. with and without load spreading washers, or staggered fixings etc.*
*The reason for this level of static load checking (1 in 3) is because of the varying loads placed on the fixings by different purlin spacings and span configuration. It is therefore not critical as to which span is cyclically tested but it is recommended that the median of the three spans be cyclically tested.*

*Because the cyclic test is a verification test only to demonstrate that the static test would not fail under repeated load, it does not require to be factored by the factors in 17.1.1A Variability Factors.*

**C6.4.**

*The cyclic regime used for New Zealand does not follow the Australian or other models.*
*1000 cycles at 80% of the target load, cycling from 40%-80% of the target load.*

*1000 cycles at 90% of the target load, cycling from 45%-90% of the target load.*

*1000 cycles at 100% of the target load, cycling from 50%-100% of the target load.*

*The reason why the cycle is not dropped to zero is because gusting under storm conditions more closely resembles these sequences.*

**C.7. (j) & (k). Deflection.**

*One of the reasons why deflection is regarded as a performance criterion in Australia is because of ponding. Although rainfall does not normally occur at maximum wind load, in adverse circumstances standing waves and turbulence could still give leakage at the minimum pitch allowable in Australia (1°).*
*It is for this reason as well as many others that NZ has adopted 3° as a minimum pitch.*

*Note 5 following Table C1of AS/NZS 1170 states:*

*Problems with visually sensed deflections are frequently dependent on the presence of a visual clue for the observer to gauge linearity. Deflections are therefore a function of the line of sight of the observer.*

*Although measured deflection under load is a performance indicator, performance under load is not considered a test criterion. The deflection design criteria also must be material non-specific, so the use of different metals and plastic for roof and wall cladding could impose unnecessary limitations on the use of these materials because they possess a very different Young's Modulus compared to steel.*

*Residual deflection is therefore set to a lower level at L/400 than would be normal for HS steel at L/1000.*

# 18 Useful Information

Useful tools and tables to do calculations and conversions for roof and wall cladding. Just choose the correct online caculator, input your values, and get the answer.

# 18.1 Conversion Factors

| 1 | = | 1013.25 |
|---|---|---|
| | | millibar |

## 18.1A Measurement Conversions

| *To convert from this* | *into this*<br>*To convert this back* | *multiply by this*<br>*divide by this* |
|---|---|---|
| *atmosphere* | *millibar* | *1013.25* |
| *atmosphere* | *pascal* | *101.325* |
| *cubic foot* | *cubic metre* | *0.028317* |
| *cubic inch* | *cubic millimetre* | *16387.1* |
| *cubic yard* | *cubic metre* | *0.764555* |
| *foot* | *metre* | *0.3048* |
| *foot per minute* | *metre per minute* | *0.3048* |
| *foot per minute* | *metre per second* | *0.00508* |
| *foot per second* | *metre per second* | *0.3048* |
| *foot pound force per second* | *watt* | *1.35582* |
| *gallon (Imp)* | *litre* | *4.54609* |
| *gallon (US)* | *litre* | *3.78541* |
| *inch* | *metre* | *0.0254* |
| *inch* | *millimetre* | *25.4* |
| *inch mercury* | *kilopascal* | *3.38638* |
| *inch water gauge* | *kilopascal* | *0.248642* |
| *kilogram* | *kN* | *102* |
| *kilometre per hour* | *knot* | *0.539* |
| *knot* | *kilometre per hour* | *1.852* |
| *knot* | *nautical mile/h* | *1* |
| *knot* | *ft/h* | *6080* |
| *knot* | *metre per second* | *0.515* |
| *metre Head of water* | *kPa* | *9.8* |
| *mile* | *kilometre* | *1.609344* |
| *mile per hour* | *kilometre per hour* | *1.609344* |
| *millimetre mercury* | *kilopascal* | *0.133322* |
| *millimetre water gauge* | *pascal* | *9.78904* |
| *MPa* | *kip* | *6.895* |
| *ounce* | *gram* | *28.3495* |
| *ounce per square foot* | *gram per square metre* | *305.152* |
| *ounce per square yard* | *gram per square metre* | *33.9057* |

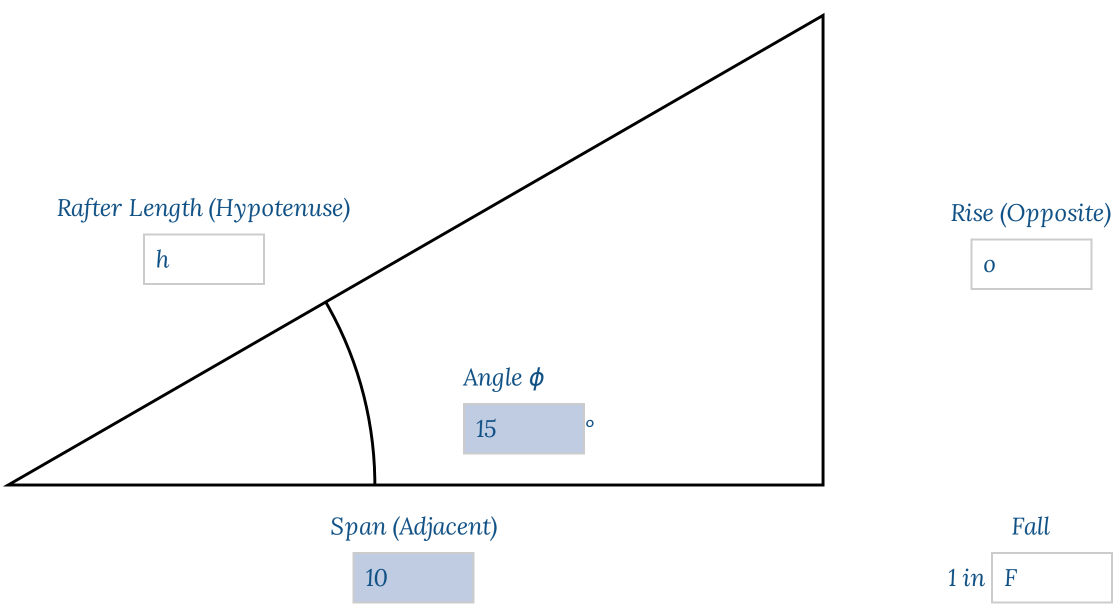
| To convert from this | into this<br>To convert this back | multiply by this<br>divide by this |
|---|---|---|
| pound | kilogram | 0.45359237 |
| pound force | newton | 4.44822 |
| pound force foot | newton.metre | 1.35582 |
| pound force inch | newton.metre | 0.112985 |
| pound force per square foot | kilopascal | 0.0479 |
| pound force per square inch | bar | 0.69 |
| pound force per square inch | pascal | 6894.76 |
| pound force per square inch | kilopascal | 6.89476 |
| pound force per square inch | megapascal | 0.006895 |
| pound per cubic foot | kilogram per cubic metre | 16.0185 |
| pound per foot | kilogram per metre | 1.48816 |
| pound per square foot | kilogram per square metre | 4.882 |
| square foot | square metre | 0.092903 |
| square foot per ton | square metre per tonne | 0.091436 |
| square inch | square millimetre | 645.16 |
| square mile | square kilometre | 2.59 |
| square yard | square metre | 0.836127 |
| Steel thickness in mm | Weight of steel kgs/$m^2$ | 7.85 |
| ton | tonne | 1.01605 |
| ton force foot | kilonewton metre | 3.03703 |
| ton force per square inch | megapascal | 15.4443 |
| ton per cubic yard | tonne per cubic metre | 1.32894 |
| ton, freight (40 $ft^3$) | cubic metre | 1.13267 |
| yard | kilometre | 0.000914 |

Water 0˚ – 100˚ increases in volume by 4.4%
1 litre = 1 kg = 0.001 m3
1 m3 = 1000 litres
Weight of steel kgs/m2 = thickness in mm x 7.85
1 kN = 102 kg
1 kip = 6.895 MPa

## 18.2
## Roof Pitch Tangent

*The relationship between the pitch, fall or rise and the horizontal, is the relationship between the opposite and the adjacent sides of a right angled triangle.*
*This is known as the tangent of the angle. (tan ϕ) with the opposite side being the rise and the adjacent side the horizontal distance.*

*Enter any two values on the illustration for live calculations.*




### 18.2A Rafter, Hip and Rise Chart

| Pitch | Rafter length | Hip/Valley Length | Vertical Rise | Valley Angle |
|---|---|---|---|---|
| | per metre span | per metre span | per metre span | |
| 0.5 | 1.000 | 1.414 | 0.009 | 179° |
| 1 | 1.000 | 1.414 | 0.017 | 179° |
| 1.5 | 1.000 | 1.414 | 0.026 | 178° |
| 2 | 1.001 | 1.415 | 0.035 | 177° |
| 3 | 1.001 | 1.415 | 0.052 | 176° |
| 4 | 1.002 | 1.416 | 0.070 | 174° |
| 5 | 1.004 | 1.417 | 0.087 | 173° |
| 6 | 1.006 | 1.418 | 0.105 | 172° |
| 7 | 1.008 | 1.420 | 0.123 | 170° |
| 8 | 1.010 | 1.421 | 0.141 | 169° |
| 9 | 1.012 | 1.423 | 0.158 | 167° |
| 10 | 1.015 | 1.425 | 0.176 | 166° |

| | | | | |
|---|---|---|---|---|
| 11 | 1.019 | 1.428 | 0.194 | 164° |
| 12 | 1.022 | 1.430 | 0.213 | 163° |
| 13 | 1.026 | 1.433 | 0.231 | 162° |
| 14 | 1.031 | 1.436 | 0.249 | 160° |
| 15 | 1.035 | 1.439 | 0.268 | 159° |
| 16 | 1.040 | 1.443 | 0.287 | 158° |
| 17 | 1.046 | 1.447 | 0.306 | 156° |
| 18 | 1.051 | 1.451 | 0.325 | 155° |
| 19 | 1.058 | 1.456 | 0.344 | 153° |
| 20 | 1.064 | 1.460 | 0.364 | 152° |
| 21 | 1.071 | 1.465 | 0.384 | 151° |
| 22 | 1.079 | 1.471 | 0.404 | 149° |
| 23 | 1.086 | 1.477 | 0.424 | 148° |
| 24 | 1.095 | 1.483 | 0.445 | 147° |
| 25 | 1.103 | 1.489 | 0.466 | 145° |
| 26 | 1.113 | 1.496 | 0.488 | 144° |
| 27 | 1.122 | 1.503 | 0.510 | 143° |
| 28 | 1.133 | 1.511 | 0.532 | 141° |
| 29 | 1.143 | 1.519 | 0.564 | 140° |
| 30 | 1.155 | 1.528 | 0.577 | 139° |
| 31 | 1.167 | 1.537 | 0.601 | 137° |
| 32 | 1.179 | 1.546 | 0.625 | 136° |
| 33 | 1.192 | 1.556 | 0.649 | 135° |
| 34 | 1.206 | 1.567 | 0.675 | 133° |
| 35 | 1.221 | 1.578 | 0.700 | 132° |
| 36 | 1.236 | 1.590 | 0.727 | 131° |
| 37 | 1.252 | 1.602 | 0.754 | 130° |
| 38 | 1.269 | 1.616 | 0.781 | 128° |
| 39 | 1.287 | 1.630 | 0.810 | 127° |
| 40 | 1.305 | 1.644 | 0.839 | 126° |
| 41 | 1.325 | 1.660 | 0.869 | 125° |
| 42 | 1.346 | 1.677 | 0.900 | 124° |
| 43 | 1.367 | 1.694 | 0.933 | 122° |
| 44 | 1.390 | 1.712 | 0.966 | 121° |
| 45 | 1.414 | 1.732 | 1.000 | 120° |
| 46 | 1.440 | 1.753 | 1.036 | 119° |
| 47 | 1.466 | 1.775 | 1.072 | 118° |
| 48 | 1.494 | 1.798 | 1.111 | 117° |
| 49 | 1.524 | 1.823 | 1.15 | 115° |
| 50 | 1.556 | 1.849 | 1.192 | 114° |
| 51 | 1.589 | 1.877 | 1.235 | 113° |
| 52 | 1.624 | 1.907 | 1.280 | 112° |
| 53 | 1.662 | 1.939 | 1.327 | 111° |
| 54 | 1.701 | 1.973 | 1.376 | 110° |
| 55 | 1.743 | 2.010 | 1.428 | 109° |

| | | | | |
|---|---|---|---|---|
| 56 | 1.788 | 2.049 | 1.483 | 108° |
| 57 | 1.836 | 2.091 | 1.540 | 107° |
| 58 | 1.887 | 2.136 | 1.600 | 106° |
| 59 | 1.942 | 2.184 | 1.664 | 105° |
| 60 | 2.000 | 2.236 | 1.732 | 104° |

## 18.3

## Material Density, Melting Point, Expansion And Modulus

## 18.3A Density, Melting Point, Expansion and Young Modulus

| Material | Density kg/m³ | Melting point °C | Expansion mm/10m/100°C | Youngs modulus Gpa |
|---|---|---|---|---|
| **Air** | 1.29 | | | |
| **Air acetylene** | | 2500* | | |
| **Aluminium,** rolled | 2710 | 658 | 24 | 69 |
| **Brass** | 8330 | 900 | 18 | |
| **Carbon Dioxide** 0°C | 1.99 | | | |
| **Cement** | 1281 | | | |
| **Concrete,** reinforced 2% steel | 2420 | | | |
| **Copper** | 8938 | 1083 | 17 | 131 |
| **Glass** | 2787 | 850 | 9 | |
| **Gold** | 19290 | 1063 | 14 | |
| **Hydrogen** 0°C | 0.0897 | | | |
| **Helium** 0°C | 0.178 | | | |
| **Ice** | 913 | 0 | | |
| **Iron,** cast | 7208 | 1530 | 12 | 179 |
| **Lead,** rolled | 11325 | 327 | 29 | 16 |
| **Nitrogen** 0°C | 1.25 | | | |
| **Oxygen** 0°C | 1.43 | | | |
| **Oxy acetylene** | | 4400* | | |
| **Pinus Radiata** | 609 | | | 6 |
| **Polycarbonate** | 1244 | 133 | 64 | |
| **Polyester** | 1299 | 245 | 80# | |
| **P.V.C.** | 1465 | 86 | 140 | |
| **Silver** | 10500 | 960 | 19 | |
| **Silver solder** | | 735 | | |
| **Easy-flo** | | 630 | | |
| **Solder Lead 50%** | 9302 | 210 | | |
| **(Eutectic) Lead 33%/tin 67%** | 8615 | 180 | | |
| **Snow:** fresh | 96 | 1 | | |
| wet compact | 320 | | | |
| **Stainless Steel 304** | 8080 | 1425 | 17 | 193 |
| **Stainless Steel 316** | 8080 | 1385 | 16 | 193 |
| **Steel,** low carbon | 7850 | 1350 | 12 | 200 |
| **Tin** | 7280 | 231 | 27 | |
| **Water:** fresh 4°C | 1000 | | | |
| **Water:** fresh 20°C | 988 | | | |
| **Water:** fresh 100°C | 958 | | | |
| **Water:** salt | 1009-1201 | | | |
| **Zinc:** rolled | 7192 | 419 | 29 | |

* max flame temperature
# glass reinforced polyester GRP expansion = 22

To convert Centigrade to Farenheit.
To convert Farenheit to Centigrade.
C° = F° - 32° x .56
F° = C° x 1.8 + 32°

## 18.3.1 Thermal Conductivity K

### 18.3.1A Thermal Conductivity

| Material | W/mK |
|---|---|
| Copper | 385 |
| Aluminium | 205 |
| Zinc | 108 |
| Steel | 50 |
| Lead | 35 |
| Stainless Steel | 16 |
| Ice | 2 |
| Glass | 1.05 |
| Concrete | 0.94 |
| Brick | 0.8 |
| Water (20°C) | 0.56 |
| Timber (Pine) | 0.14 |
| Snow | 0.1 |
| Kraft building paper | 0.07 |
| Fibreglass | 0.035 |
| Rockwool | 0.035 |
| Polystyrene | 0.035 |
| Air (20°C ) | 0.025 |
| Polyurethane (Rigidised) | 0.016 |

# 18.4 Decadic Number System

## 18.4A Decadic Numbers

| Symbol | Designation | Long Measure | | | Multiplier |
|---|---|---|---|---|---|
| T | Tera | Billion (Trillion | | | $10^{12}$ |
| G | Giga | Milliard (Billion USA) | | | $10^{9}$ |
| M | Mega | Million | | | $10^{6}$ |
| ma | Myria | Ten thousand | mam | Myriametre | $10^{4}$ |
| k | Kilo | Thousand | km | Kilometre | $10^{3}$ |
| h | Hecto | Hundred | hm | Hectometre | $10^{2}$ |
| da | Deca | Ten | dam | Decametre | 10 |
| | | One | m | Metre | 1 |
| d | Deci | Tenth | dm | Decimetre | $10^{-1}$ |
| c | Centi | Hundredth | cm | Centimetre | $10^{-2}$ |
| m | Milli | Thousandth | mm | Millimetre | $10^{-3}$ |
| µ | Micro | Millionth | | Micrometre (Micron) | $10^{-6}$ |
| n | Nano | Milliardth | nm | Nanometre | $10^{-9}$ |
| p | Pico | Billionth | pm | | $10^{-12}$ |

# 18.4.1 International Symbols

## 18.4.1A The Greek Alphabet

| Upper | | Lower | | Greek |
|---|---|---|---|---|
| Α | A | α | a | alpha |
| Β | B | β | b | beta |
| Γ | G | γ | g | gamma |
| Δ | D | δ | d | delta |
| Ε | E | ε | e | epsilon |
| Ζ | Z | ζ | z | zeta |
| Η | H | η | h | eta |
| Θ | Q | θ | q | theta |
| Ι | I | ι | i | iota |
| Κ | K | κ | k | kappa |
| Λ | L | λ | l | lambda |
| Μ | M | μ | m | mu |
| Ν | N | ν | n | nu |
| Ξ | J | ξ | j | xi |
| Ο | O | ο | o | omicron |
| Π | P | π | p | pi |
| Ρ | R | ρ | r | rho |
| Σ | S | σ | s | sigma |
| Τ | T | τ | t | tau |
| Υ | Y | υ | y | upsilon |
| Φ | F | φ | f | phi |
| Χ | X | χ | x | chi |
| Ψ | C | ψ | c | psi |
| Ω | V | ω | v | omega |

## 18.5 Geometry And Mensuration

Enter values below for automatic calculations

| | |
|---|---|
| a | = area |
| b | = base |
| d | = diameter |
| h | = height |
| l | = length |
| r | = radius |
| π | = 3.1416 |
| c | = circumference = 2πr or 22/7d |

### Areas

| | |
|---|---|
| Circle | = $\pi r^2$ or 0.7854 $d^2$ |
| Square, rectangle, rhombus or rhomboid | = bh |
| Triangle | = .5 bh |
| Trapezoid | = .5 two parallel sides x h |
| Side of square of area equal to circle | = 0.8862 d |
| Diameter of circle equal in area to square | = 1.1284 side of square |
| Parabola | = .66 bh |
| Ellipse | = 0.7854 d1 d2 |

Area of any figure of four or more unequal sides is found by dividing it into triangles, finding areas of each and adding together.

### Surface Area

| | |
|---|---|
| Cube | = $6b^2$ |
| Sphere | = $\pi d^2$ |
| Lateral surface area of regular figure | = .5 cb*h (slant height)* |
| Cylinder (Lateral surface area) | = πdh |
| Cylinder (Total surface area) | = πdh + 2πr2 |
| Cone (Total surface area) | = ab + c of base x .5*h (slant height)* |

### Volume

| | |
|---|---|
| Cube | = $b^3$ |
| Sphere | = 0.5236 $d^3$ |
| Pyramid | = .33 abh |
| Cone | = .33 abh |

Cylinder = $\pi r^2 h$

## Table of polygons

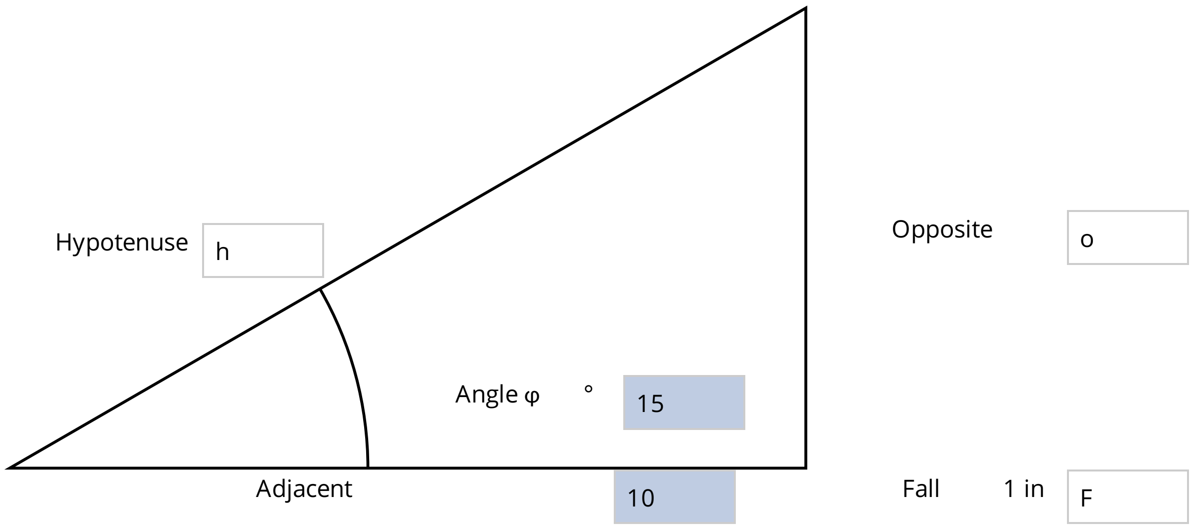
| | |
|---|---|
| S | = side of polygon. |
| R | = Radius of circumscribed circle. |
| r | = Radius of inscribed circle. |
| A | = Angle formed by the intersection of the sides. |

| Name | No of sides | Angle |
|---|---|---|
| Trigon | 3 | 60° |
| Pentagon | 5 | 108° |
| Hexagon | 6 | 120° |
| Octagon | 8 | 135° |
| Decagon | 10 | 144° |

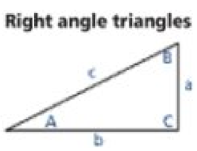
Area of any regular polygon = Radius of inscribed circle x 1/2 number of sides x length of one side.

## Right Angle Triangles

Enter any two values on the illustration for live calculations.




## 18.5A Triangle Values

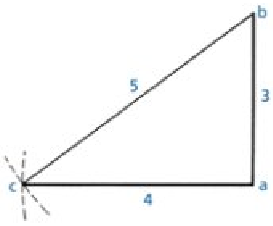



| Find | Given | Solution |
|---|---|---|
| A | a, b | tan A = a / b |
| | a, c | sin A = a /c |
| | b, c | cos A = b / c |
| B | a, b | tan B = b / a |
| | a, c | cos B = a / c |
| | b, c | sin B = b / c |

| | | |
|---|---|---|
| a | A, b | b tan A |
| | A, c | c sin A |
| | b, c | √ $c^2$ - $b^2$ |
| b | A, a | a / tan A |
| | A, c | c / cos A |
| | a, c | √ $c^2$ - $a^2$ |
| c | A, a | a / sin A |
| | A, b | b / cos A |
| | a, b | √ $a^2$ + $b^2$ |
| Area | a, b | ab / ² |

## 18.5B To Find a Right Angle

Draw a line ab 3x long. At point a scribe an arc 4x long.
At point b scribe an arc 5x long to intersect a c.
Join ac and b, ac and ab are at 900.



# 18.6 Velocities



## 18.6A Velocity

| Unit | m/s | kms/h | mile/h |
|---|---|---|---|
| mile / hour | 0.44704 | 1.60934 | 1 |
| m/s | 1 | 3.6 | 2.23694 |
| km/h | 0.277778 | 1 | 0.62137 |

*Velocity is the distance travelled in one second (m/s).*
*The following speeds are approximate and are assumed to be constant and in a straight direction and therefore are also the velocity.*

*Description marked R are speed records.*

## 18.6B Velocity Comparison

| | ***m/s*** | ***km/h*** | ***mile/hour*** | ***Beaufort Scale*** |
|---|---|---|---|---|
| *Calm* | *0* | *<1* | *0* | *Smoke rises vertically* |
| *Light Air* | *0.8* | *3* | *2* | *1 Smoke rises on angle* |
| *Man walking* | *1.5* | *5.5.* | *3.5* | |
| *Light breeze* | *2.5* | *9* | *5.6* | *2 Feel wind on face* |
| *Gentle breeze* | *4.5* | *16* | *10* | *3 Flags extend* |
| *Moderate breeze* | *7* | *25* | *15.5* | *4 Raises dust* |
| *Fresh breeze* | *10* | *35* | *22* | *5 Trees sway, waves* |
| *Runner 100m R* | *10* | *35* | *22* | |
| *Strong breeze* | *12.5* | *45* | *28* | *6 Telegraph wires whistle* |
| *Racehorse trotting R* | *15* | *54* | *33* | |
| *Moderate gale* | *15.5* | *56* | *35* | *7 Difficult to walk* |
| *Fresh gale* | *18.5* | *67* | *42* | *8 Branches break* |
| *Racehorse R* | *19* | *68* | *42.5* | |
| *Ostrich* | *20* | *72* | *45* | |
| *Racing cyclist R* | *22* | *79* | *49* | |
| *Strong gale* | *23* | *82* | *51* | *9 Slight building damage* |
| *Whole gale* | *26.5* | *96* | *60* | *10 Trees uprooted* |
| *N.Z. Road speed limit* | *28* | *100* | *62.5* | |
| *Skier downhill* | *28* | *100* | *62.5* | |
| *Storm* | *31* | *111* | *69* | *11 Widespread damage* |
| *Low wind speed NZS 3604* | *32* | *115* | *71* | |
| *Hurricane* | *33.5* | *120* | *75* | *12 Severe damage* |
| *Medium wind speed NZS 3604* | *37* | *133* | *83* | |
| *High wind speed NZS 3604* | *44* | *158* | *98* | |

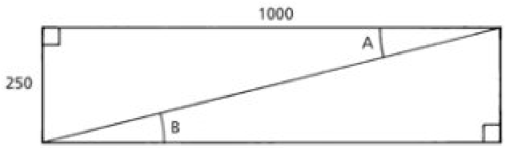
| | m/s | km/h | mile/hour | Beaufort Scale |
|---|---|---|---|---|
| AS/NZS 1170 | 45 | 162 | 101 | |
| Swift - fastest bird | 47 | 169 | 105 | |
| Very high wind speed NZS 3604 | 50 | 180 | 111 | |
| AS/NZS 1170 (Cook Strait) | 51 | 184 | 114 | |
| Moderate cyclone | 55 | 198 | 153 | |
| Tennis serve R | 66 | 238 | 148 | |
| Bullet train (Japan) | 69 | 248 | 154 | |
| Severe tropical cyclone | 70 | 252 | 157 | |
| TGV express train | 77 | 277 | 172 | |
| Wind R | 103 | 371 | 230 | |
| Boeing 747 | 256 | 920 | 572 | |
| Sound in air | 333 | 1199 | 743 | |
| Land speed R | 341 | 1228 | 763 | |
| Rotation of earth at equator | 465 | 1674 | 1040 | |
| Concorde | 649 | 2336 | 1452 | |
| 303 Bullet | 792 | 2851 | 1772 | |
| Lockheed Blackbird R | 981 | 3529 | 2193 | |
| Moon round the earth | 1000 | 3600 | 2237 | |
| Sound through steel | 5100 | 18360 | 11408 | |
| To escape earth’s gravity | 7823 | 28163 | 17500 | |
| Fastest man has travelled | 11176 | 40234 | 25000 | |
| Earth round the sun | 29700 | 106920 | 66437 | |
| Pioneer space probe | 66720 | 240192 | 149248 | |
| Light and electric waves | 299388000 | 1077614064 | 669600000 | 186,000 miles/sec |

# 18.7 Cricket Penetration Patterns

When cricket and diverter penetration flashings are used, the pitch of the cricket valley will always be less than the pitch of the roof.

To find the pitch of a roof or valley, a simple method is to use a 1m long level measuring stick and measure the rise as shown in drawing 18.7A Measuring Stick Method. The relationship between the rise and the horizontal distance is known as the tangent of the angle and is calculated by using tan f = O/A (being the opposite side divided by the adjacent side). See 18.2 Roof Pitch Tangent.

## 18.7A Measuring Stick Method



Drawing 18.8.A

250/1000 = 0.25 = 14° (1 in 4)

N.B. Angles A and B are equal.

It is possible to obtain the length of the hypotenuse by using √ a2 + b2

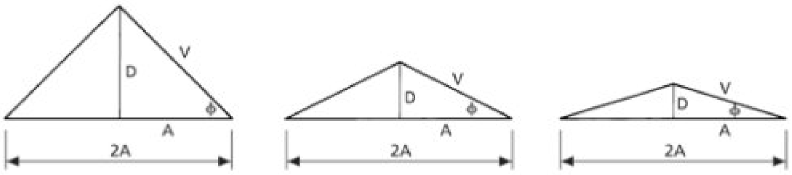
Cricket flashings as described in section 6 can be made to suit any penetration width, any cricket flashing depth to width ratio and roof pitch down to 3°. For simplicity, three angles have been selected.

f X = 45°
f Y = 27°
f Z = 18°

VARIATION OF CRICKET VALLEY DESIGN DEPENDENT ON DEPTH AND ROOF PITCH

*Penetration Width* = 2A
*Depth* = D
*Valley* = V

## 18.7B Cricket Variations



Drawing 18.8.B

f X = 45°
D = A
V = √2 = 1.42

f Y = 27°
D = 1/2A
V = √1.25 = 1.118

f Z = 18°
D = 1/3A
V = √1.11 = 1.054

*To find the cricket valley pitch when the roof pitch is known, it is necessary to find the depth (D) of the cricket. If the depth of the cricket is half of the width of the penetration, as shown for 'Cricket X' the angles are at 45° and there is a defined relationship between the length of the valley of the cricket and the width of the penetration and also between the pitch of the valley of the cricket and the pitch of the roof.*

*This is 1 : √ 2 = 1.42, which means that to maintain the desired 3° fall in the cricket valley, the minimum roof pitch (4°) can be calculated using table 15.8.*

*If the depth of the cricket is a quarter or a sixth of the width of the penetration, there are also defined relationships between the pitch of the valley of the cricket and the pitch of the roof.*

*These are described in table 18.7C as 'Cricket Y' and 'Cricket Z'.*

*All figures comply with the minimum fall of 1.5°, but all the bold figures will provide a 3° cricket valley pitch. This methodology is valid for all sizes of penetration. However, there is a point at which, having a design with a wide penetration and a low pitch, it becomes uneconomic to pursue the ideal 3° fall in the cricket valley. When the roof pitch is known, the minimum allowable fall of the cricket valley pitch (1.5°) can then be read from table 15.8.*

*It is permissible to lower the valley pitch because 1.5° allows sufficient fall to clear debris from the valley and therefore qualifies as a warrantable flashing.*

*A diverter flashing without a cricket design only shifts the position of the cricket to the top over-flashing of the penetration as shown on drawing 9.7.6B Cricket Flashings, unless the penetration is rotated 45° as shown on drawing 9.7.6C Diverter Flashings.*

## 18.7C

| ROOF PITCH | 3° | 4° | 5° | 6° | 7° | 8° | 9° | 10° |
|---|---|---|---|---|---|---|---|---|
| TANGENT | .0524 | .0699 | .0875 | .1051 | .1228 | .1405 | .1584 | 1763 |
| CRICKET X | 2° | **3°** | **3.5°** | **4.5°** | | | | 10° |
| CRICKET Y | 1.5° | 1.75° | 2.25° | 2.75° | **3.25°** | 8° | 9° | 10° |
| CRICKET Z | n/a | n/a | 1.5° | 2° | 2.25° | 2.5° | **3°** | **3.5°** |

*PROCEDURE TO MAKE A HALF PATTERN FOR A CRICKET PENETRATION FLASHING*

*Example:*

*A net penetration width is 550 mm wide and gross width to the flat of the pans is 620 mm (2A).*

*The back curb is required to have a fall of 3°.*

*The roof pitch is 7°.*

*From Table 18.7C . select the cricket - Type Y*

*Given:*

| | |
|---|---|
| *Half the width of the cricket* | *A = 310mm* |
| *Depth of the Y cricket from drawing 15.8.B (D=1/2A)* | *D = 155mm* |
| *Height of the side curb* | *H = 130mm* |
| *Height to the top of the cricket* | *Hc = 70mm* |
| *H - Hc = Hr* | *Hr = 60mm* |

*From Drawing 15.8.C*

*Find the length of V, S and R.*

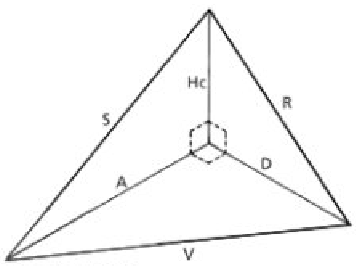
*Right angle triangle, therefore, the length of V.* $V = \sqrt{A2 + D2}$ $= 346$ *mm*

*Right angle triangle, therefore, the length of R.* $R = \sqrt{Hc^2 + D^2}$ $= 170$ *mm*

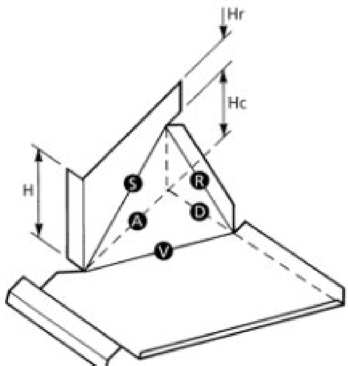
*Right angle triangle, therefore, the length of S.* $S = \sqrt{A^2 + Hc^2}$

$= 318$ *mm*

## 18.7D Cricket Pattern



Drawing 18.8.C

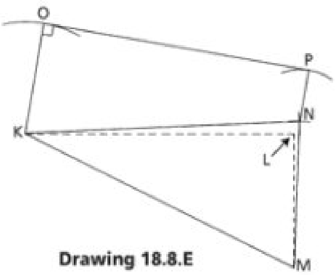


Drawing 18.8.D

*DRAW A HALF PATTERN*

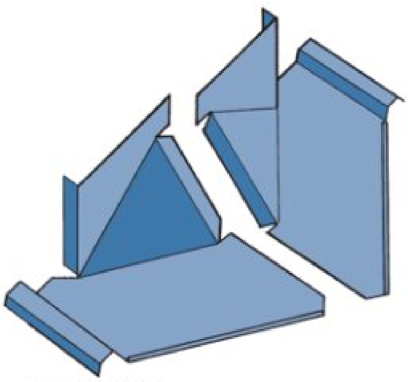
1. *Draw a dotted line K - L length equal to A*
2. *From L draw a dotted line at right angles L - M length equal to D*
3. *Draw the line K - M (length equal to V)*
4. *With centre M scribe an arc length equal to R*
5. *With centre K scribe an arc length equal to S*
6. *From their point of intersection, N draw a line to K and also to M*
7. *With centre K scribe an arc length equal to H.*
8. *With centre N scribe an arc length equal to Hr.*
9. *Draw a line as a tangent to the two arcs*
10. *From point K, draw a line at right angles to intersect this line at O.*
11. *From O measure length A to a point P*
12. *The shape K-M-N-P-O is the net cricket pattern*

## 18.7E




Drawing 18.8.E

## 18.7F



Drawing 18.8.F

## 18.8
## Sheet Metal Work For Roofing Contractors.

*When forming various flashings in sheet-metal the Roofing Contractor is required to know how to cut his material in order to obtain the desired shape.*
*A basic knowledge of geometrical drawing and mensuration is required and this section explains the methods which are employed to ensure accurate results.*

***A straight line.*** *A straight line is a line drawn in the shortest manner between two given points, so any other line between these points is a curved line.*

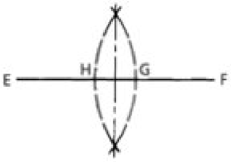
***Parallel lines.*** *Parallel lines are lines which, when extended, do not touch. Given a line CD, to draw a parallel line set a compass to the required distance apart and with C and D as centres, describe two arcs. A line drawn as a tangent to both arcs will be a parallel line to CD.*

### 18.8A


***To draw a perpendicular line.*** *Given a straight line EF, set a compass to any distance more than half the distance EF and, with E and F as centres, describe arcs of radius EG and FH.*

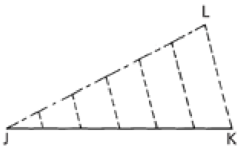
*A line drawn through the points of intersection of these arcs is perpendicular to EF, and bisects the distance EF.*

### 18.8B




***To divide a line into any number of equal parts.*** *Given a straight line J K, draw another line J L at any suitable angle and no particular length. Set off on JL, at any reasonable distance apart, a number of equal spaces similar in number to the parts into which JK is to be divided.*
*Connect L and K with a line, and parallel to this draw other lines through points on JL. These divide JK into the required number of equal parts.*

### 18.8C

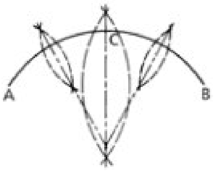


***To bisect an arc.*** *Given an arc AB, set a compass to a distance a little more than half that between the ends and with A and B as centres, describe arcs of equal radii.*

*A line drawn through the points of intersection will bisect AB. This method can be employed to divide the arc into any number of even parts by repetition. Further, the method may be used to find the centre of any given arc by further bisecting AC and CB.*

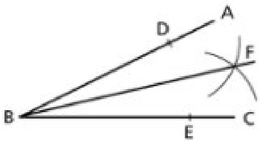
*Lines taken through the intersecting points of these latter arcs, when produced, will intersect at the centre of the arc AB.*

## 18.8D



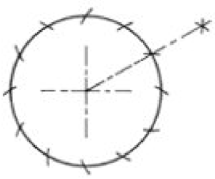

***To bisect an angle.*** *Given an angle ABC, set off equal distances BD and BE and with D and E as centres and a compass set at any reasonable radius, describe arcs to intersect in F. A line drawn through B and F bisects the angle.*

## 18.8E




***To divide a circle into six equal parts.*** *Set a compass to the radius of the circle and step this distance off along the circumference. Further division into 12 parts may be done by bisecting one part, and again steppingoff with the radius of the circle*

## 18.8F



***Development of the frustrum of a true cone.***
*Draw the elevation X with base diameter AB, the vertical height CD to the desired cone angle and add the section line EF to the elevation. With centre D and radius DA describe a semicircle Y on the base, and divide the circumference of this into six equal parts.*

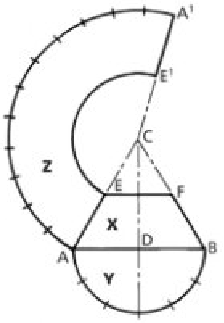
*To draw the development Z: With centre C and radius CB, describe an arc $AA^1$ whose length equals the circumference of cone base.*

*This may be obtained by marking off along the arc from A spaces equal to parts in the semicircle Y but double in number.(12)*

*With C as centre and radius CE, draw the arc EE1 and add the line $CA^1$.*

*The figure AA1E1E is the development Z of the frustrum.*

## 18.8G




*To do this, drop a perpendicular from F to $F^1$ and extend the base line AB.*

*An offset diagram is now made by measuring distances $B^1F^1$, $B^1G$, and $B^1H$, setting these off from $F^1$ on base line AB and drawing lines to F.*

*The lengths $FF^1$, FG, and FH, etc., are now true lengths.*

*To draw the development Z:*

*Draw a centre line $C^1O$. At right angles to $C^1$ draw $A^2B^2$ equal to AB.*

*From C1, set off distance C1F1, equal to FB.*

*Join $A^2$ and $B^2$ to $F^1$. With centre $A^2$ and radius $F^1G$, draw a short arc to be cut by an arc of $F^1G$ radius struck from F1 to obtain point G1.*

*Similarly, with $A^2$ as centre and radius FH, draw an arc, to be cut by an arc of GH radius struck from point $G^1$, thus obtaining point $H^1$.*

*Draw a line through, $A^2$ and $H^1$ and produce same to intersect the centre line $C^1O$ at O.*

*Repeat the process with. $B^2$ as centre for long radii, thus completing one quarter of the whole development.*

*To complete the pattern, draw a curve through points $H^1G^1F^1$ and repeat in the other sections of the development.*

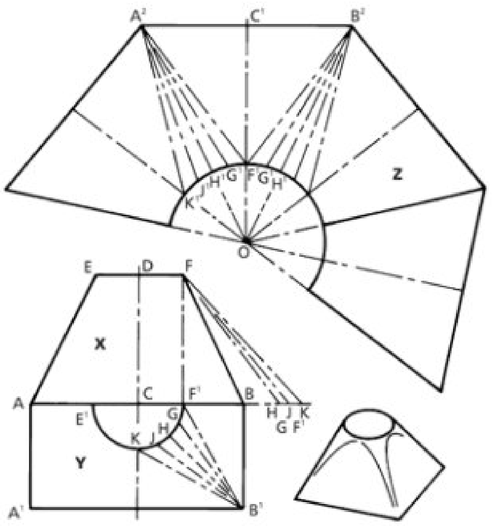
***Development of a square base to a circular top.***
*Draw the elevation X, making the base AB, vertical height CD, and diameter of top EF.*

*Draw a half plan Y on the base, drawing the semicircle E1F1 and dividing one half of this into a number of equal parts, $F^1G$, GH, HJ, and JK.*

*Through points $F^1$, G, H, J, and K, draw lines to $B^1$.*

*Before proceeding to the development it is necessary to find the true lengths of $B^1K$, $B^1J$, $B^1H$, $B^1G$, and $B^1F^1$.*

## 18.8H



# 19 Revision History

## Policy for Updates to NZ Metal Roof and Wall Cladding Code Practice.

All revisions to clauses of the COP after June 2018 are recorded at 19 Revision History, including a brief explanation of the change.

See sub-clauses for detail of revisions at particular dates.

Revisions are split into 3 categories for simple assessment by users:

## 19A Revision Categories

| Category | Description | Notification |
|---|---|---|
| Category 1 - Minor Errata | Correction to spelling, grammar or formatting that have no bearing on on the substance of the clause. | Recorded on website only - not individually included in emailed update |
| Category 2 - Editing and rearrangement | A clause or section of clauses has been rewritten to some extent for better articulation of the existing recommendation.<br><br>Existing citations of the COP in project documentation may be less clear as a result, but recommendations are not altered. | Recorded on website, and will be cited in emailed update as either specific or summary information as appropriate. |
| Category 3 - Substantial change to recommendation | A substantial change in a specific recommendation of the COP has taken place.<br><br>A review of existing project documentation against the new clause is considered essential. | Recorded on website, and explained with detail in emailed update |

# 19.1 2019 – February

The following updates to the NZ Metal Roof and Wall Cladding Code Practice (COP), is effective 1 February 2019.

In this update, no recommendations have been altered that would require changes to existing projects in progress.

**Summary of Changes in this Update**

- Two new clauses were added in 3 *Structure* to discuss 3.13 Material Grade and 3.14 Material Thickness.
- Two new, separate, clauses under 4.16 Clearances, discuss 4.16.1 Ground Clearance and related 4.16.2 Site Management in more detail.
- Clauses dealing with 3.12.1 Screw Fasteners fixing to specific purlin types re-ordered for clarity.
- New drawing to show recommended 9.4A Penetration Type at Recommended Position.
- Other updates consist of Category 1 – minor errata corrections to spelling, and grammar and layout.

| Category | Clause Number (at time of update) | Clause (As of current publication) | Details |
|---|---|---|---|
| 2 - Editing and rearrangement | 3.12.1 | 3.12.1 Screw Fasteners | Clauses dealing with fixing to specific purlin types re-ordered for clarity. |
| 1 - Minor Errata | 3.13.1 | 3.15.1 Corrugate Profile | Minor grammatical editing for clarity. |
| 1 - Minor Errata | 3.14.3 | 3.16.3 Maximum Spans for Corrugate Wall Cladding | Heading says 0.40 mm but Table is .40 and .55. So remove .40 from heading |
| 1 - Minor Errata | 4.6.1 | 4.6.1 Assessment of Marine Environments | Removed full stop from the heading. |
| 2 - Editing and rearrangement | 4.8.1 | 4.8.1 Lichen | Resized photo (4.8.1C ) and inserted photo (4.8.1D . |
| 2 - Editing and rearrangement | 4.15 | 4.15 Swarf Staining and Cut Edge Corrosion | Renamed clause. Resized photos and inserted new photo ( 4.15D Cut Edge Corrosion ) |
| 1 - Minor Errata | 4.17.3 | 4.17.3 Aluminium | fixed spelling of "quaters" to quarters |
| 1 - Minor Errata | 4.18.1.3 | 4.18.1.3 Top Coat and Backer | 0 |
| 1 - Minor Errata | 5.3.1 | 5.3.1 Catchment Area | Removed (Optional Caption) from 5.3.1A Wind-effect on Rain |
| 1 - Minor Errata | 6.1.1 | 6.1.1 E2 Objective | Set format as Block Quote |
| 1 - Minor Errata | 6.1.2 | 6.1.2 E2 Functional Requirement | Format as block Quote. |
| 1 - Minor Errata | 6.3 | 6.3 Related Topics | Changed link "Internal Moisture" to "Roof Ventilation. |
| 2 - Editing and rearrangement | 9.5.6 | 9.5.5 Sheetmetal Flashing Drawings | Revised and renamed clause. |
| 1 - Minor Errata | 14.5.1 | 14.5.1 Crest Fixing | Corrected minimum embedment into soft wood from 35mm to 30mm aligning with E2/AS1 and other reference in 3.12.1.3 Timber Purlins |

## 19.2 2018 – November

The NZ Metal Roof and Wall Cladding Code Practice (COP), has been updated effective 1 November 2018.

In this Update no recommendations have been altered that would require changes to existing projects in progress

### Summary of Changes in this Update

- The previous *External Moisture, Flashings* and *Penetrations* sections have been updated to closer reflect the requirements of NZBC Clause E2 – External Moisture.
  All clauses and sub-clauses in these sections have been substantially revised and drawings updated to show details more clearly.
  - *6 External Moisture Overview* gives a general introduction and overview of NZBC Clause E2 – External Moisture.
  - 7 External Moisture Roofing discusses requirements for roof and wall cladding.
  - *8 External Moisture Flashings* deals with flashings, seals and laps.
  - *9 External Moisture Penetrations* recommends good practice for penetration design and installation.
- Other updates consist of Category 1 – minor errata corrections to spelling, and grammar and layout.

### 19.2A

| Category | Clause Number (at time of update) | Clause (As of current publication) | Details |
|---|---|---|---|
| 2 - Editing and rearrangement | 4.5.2 | 4.5.2 Sea Spray | Moved copy dealing with corrosion from "Eaves Flashing" to "Sea Spray". |
| 1 - Minor Errata | 4.11.8 | 4.11.8 Microcracking | Correction to comparative scale of illustrations |
| 0 - Clause Removed | 6.1.1 | 7.1.1 Conduction | |
| 4 - Clause Inserted | 6.1.1 | 6.1.1 E2 Objective | E2 Objective under NZBC Clause E2 (Extract) |
| 4 - Clause Inserted | 6.1.2 | 6.1.2 E2 Functional Requirement | New clause to follow E2 Objective. |
| 4 - Clause Inserted | 6.1.3 | 6.1.3 E2 Performance Requirements | New clause to follow "Functional Requirement". |
| 0 - Clause Removed | 6.1 | 7.1 Heat | Clause removed, see 19.2A . |
| 4 - Clause Inserted | 6.1 | 6.1 NZBC Clause E2 External Moisture (Extract) | New Clause under External Moisture — General. |

| Category | Clause Number (at time of update) | Clause (As of current publication) | Details |
|---|---|---|---|
| 4 - Clause Inserted | 6.2.1 | 6.2.1 Compliance | New 2nd level clause to follow "Acceptable Solution NZBC E2/AS1" |
| 0 - Clause Removed | 6.2.2.1 | 7.4.2.1 Profile Strength | Subject now discussed in 19.2A . |
| 2 - Editing and rearrangement | 6.2.2.3 | 8.9 Flashing Expansion Details | Completely revised clause. |
| 2 - Editing and rearrangement | 6.2.2.4 | 8.9.2 Building Expansion Joints | Clause duplicated. |
| 4 - Clause Inserted | 6.2 | 6.2 Acceptable Solution NZBC E2/AS1 | New 2nd level clause to follow "Limits on Applications. " |
| 0 - Clause Removed | 6.3 | 8.15 Sealing Washers | |
| 4 - Clause Inserted | 6.3 | 6.3 Related Topics | New 1st level heading under "External Moisture — General" |
| 3 - Substantial change to recommendation | 6.5.2 | 7.1.2 Runoff | Clause completely revised. |
| 0 - Clause Removed | 6.5.3 | 7.2.3 Snow | Clause removed, combined with 19.2A . |
| 0 - Clause Removed | 6.5.4 | 7.2.4 Hail | Clause removed combined with 19.2A . |
| 2 - Editing and rearrangement | 6 | 6 External Moisture Overview | Clause completely revised to reflect all four COP clauses dealing with E2 External Moisture. |
| 3 - Substantial change to recommendation | 7.1.1 | 7.1.1 Minimum Roof Cladding Pitch | Clause completely revised. |
| 0 - Clause Removed | 7.1 | 7.1 Radiation | |
| 0 - Clause Removed | 7.1 | 8.1 Purpose | Clause removed, included in 19.2A . |
| 2 - Editing and rearrangement | 7.2.1 | 8.1.1 Flashing Durability | Completely revised and renamed clause renamed (previously "compatibility"). |
| 0 - Clause Removed | 7.2 | 7.2 Convection | |
| 2 - Editing and rearrangement | 7.2 | 7.1 Roof Pitch | Clause completely revised. To be the first sub-clause under External Moisture — Cladding. |
| 2 - Editing and rearrangement | 7.2 | 8.1 Flashing Materials | Completely revised clause |
| 4 - Clause Inserted | 7.2 | 7.2 Fastening Roofing | New sub-clause to be inserted at the end of Roof Pitch under External Moisture — Cladding. |

| Category | Clause Number (at time of update) | Clause (As of current publication) | Details |
|---|---|---|---|
| 3 - Substantial change to recommendation | 7.3.1 | 7.3.1 Temperature Range | Completely Revised and rewritten. To follow "Thermal Expansion and Contraction" under the new level 1 Clause: "Cladding" |
| 4 - Clause Inserted | 7.3.1 | 8.3.1 Flashing Laps | Completely revised and shortened clause. |
| 3 - Substantial change to recommendation | 7.3.2 | 7.3.2 Roof Cladding Expansion Provisions | Completely Revised and Rewritten. To follow "Steel Cladding Temperature Ranges" in "Thermal expansion and Contraction" under new Level 1 Clause: "Cladding". |
| 2 - Editing and rearrangement | 7.3 | 7.3 Thermal Expansion And Contraction | Completely revised and redone. To be moved under new level 1 Clause: External Moisture Cladding. |
| 0 - Clause Removed | 7.4.1.1 | 8.6.1.1 Ridge - Hip Intersections | Clause incorporated into 19.2A . |
| 2 - Editing and rearrangement | 7.4.2 | 8.4.2 Barge And Verge | Completely revised clause. |
| 0 - Clause Removed | 7.4.2.1 | 8.6.2.1 Internal Barge Flashing | Incorporated into parent clause. |
| 2 - Editing and rearrangement | 7.4.2.2 | 8.4.2.1 Ridge – barge Intersections | Completely revised clause. |
| 2 - Editing and rearrangement | 7.4.4 | 8.4.4 Apron Flashings | Completely revised clause |
| 2 - Editing and rearrangement | 7.4.4.1 | 8.4.4.1 Parapet And Apron Capping Terminations | Completely revised clause. |
| 2 - Editing and rearrangement | 7.4.4.3 | 8.4.4.3 Step Apron | Completely revised clause. Drawings updated. |
| 2 - Editing and rearrangement | 7.4.4.4 | 8.4.4.4 Eaves Flashing | Completely revised and renamed clause. (Previously "Gutter Apron"). Drawing updated. |
| 0 - Clause Removed | 7.4.5 | 8.6.5 Valley Flashings | Clause removed. Valleys are discussed in "Roof Drainage". |
| 2 - Editing and rearrangement | 7.4.6 | 8.4.5 Curved Flashings | Completely revised clause. |
| 2 - Editing and rearrangement | 7.4.6.1 | 8.4.5.1 Lockseamed Flashings | Revised clause. Information added. |
| 0 - Clause Removed | 7.4.6.2 | 8.6.6.2 Jennied Flashings | Clause removed — all references to "jennying" has been removed from "Flashings". |
| 4 - Clause Inserted | 7.4.6.3 | 8.4.5.2 Crimped Flashings | New clause under 19.2A . |
| 0 - Clause Removed | 7.4.7 | 8.6.7 Soffit Flashings | Clause removed. |
| 2 - Editing and rearrangement | 7.4 | 7.4 End Laps | Clause completely revised. |

| Category | Clause Number (at time of update) | Clause (As of current publication) | Details |
|---|---|---|---|
| 2 - Editing and rearrangement | 7.4 | 8.4 Flashing Types | The last line edited. |
| 0 - Clause Removed | 7.5.1 | 8.12.1 Unpainted Metal Cladding | Clause removed. |
| 0 - Clause Removed | 7.5.2 | 8.12.2 Ventilation and Cavities | Clause removed. |
| 0 - Clause Removed | 7.5.3 | 8.12.3 Window and Door Flashings in Metal Cladding | |
| 0 - Clause Removed | 7.5.4 | 8.12.4 Horizontal Metal Cladding | |
| 0 - Clause Removed | 7.5.5 | 8.12.5 General Principles | |
| 0 - Clause Removed | 7.5.6 | 8.12.6 Flush Window Flashings | Clause removed. |
| 0 - Clause Removed | 7.5.7 | 8.12.7 Recessed Window Flashings | Clause removed. |
| 0 - Clause Removed | 7.5.8 | 8.12.8 Butt Window Flashings | Clause removed. |
| 0 - Clause Removed | 7.5.9 | 8.12.9 Flashings For Vertical Cladding | |
| 0 - Clause Removed | 7.5.10 | 8.12.10 Alternative Flashing Designs | |
| 2 - Editing and rearrangement | 7.5 | 8.10 Metal Wall Cladding Flashings | Completely revised and renamed clause. |
| 0 - Clause Removed | 7.6 | 8.13 Flashings For Vertical Cladding | Clause removed. |
| 0 - Clause Removed | 7.7 | 8.14 Flashings For Horizontal Corrugate Cladding | Clause Removed. |
| 2 - Editing and rearrangement | 7.8.1 | 8.5.1 Primary Fasteners | Completely revised and shortened clause. |
| 2 - Editing and rearrangement | 7.8.2 | 8.5.2 Secondary Fasteners | Completely revised clause. |
| 0 - Clause Removed | 7.8.3 | 8.7.3 Secret Fixing Clips | Clause deleted. |
| 2 - Editing and rearrangement | 7.8.4 | 8.5.3 Flashing Cleats | |
| 4 - Clause Inserted | 7.8.5 | 8.5.4 Seams | Split the drawing into eight individual drawings, for improved layout. |
| 2 - Editing and rearrangement | 7.8 | 8.5 Fastening Flashings | Clause renamed. |

| Category | Clause Number (at time of update) | Clause (As of current publication) | Details |
|---|---|---|---|
| 0 - Clause Removed | 7.9.1 | 8.8.1 Properties | Clause removed. Discussed in 19.2A . |
| 2 - Editing and rearrangement | 7.9.2 | 8.6.1 Methods Of Sealing | Revised clause |
| 2 - Editing and rearrangement | 7.9.3 | 8.6.2 Surface Preparation | Clause shortened. |
| 0 - Clause Removed | 7.9.5 | 8.8.5 Sealed Laps | Clause removed see: 19.2A . |
| 0 - Clause Removed | 7.9.6 | 8.8.6 Strip Sealants | Clause removed. |
| 0 - Clause Removed | 7.9.7 | 8.8.7 Soldered Joints | Clause Removed. |
| 2 - Editing and rearrangement | 7.9 | 8.6 Sealants | Completely revised clause. |
| 0 - Clause Removed | 7.10.1 | 8.9.1 Vented Fillers | |
| 2 - Editing and rearrangement | 7.10.2 | 8.7.1 Soft Edging | Revised and renamed clause. |
| 2 - Editing and rearrangement | 7 | 8 External Moisture Flashings | Completely revised clause. |
| 4 - Clause Inserted | 7 | 7 External Moisture Roofing | New Level 1 clause. |
| 0 - Clause Removed | 8.1 | 9.1 General | Clause removed. General discussion incorporated in the introduction. |
| 2 - Editing and rearrangement | 8.2.1 | 9.2 Additional Support | Completely revised and renamed clause. |
| 2 - Editing and rearrangement | 8.2.2 | 9.3 Penetration Durability | Completely revised and renamed clause. |
| 0 - Clause Removed | 8.2.3 | 9.5 Corrosion | Incorporated into "19.2A ". |
| 0 - Clause Removed | 8.2.4 | 9.5.1 Catchment | Clause removed. |
| 0 - Clause Removed | 8.2.5 | 9.5.2 Obstruction | Clause removed. |
| 0 - Clause Removed | 8.2.6 | 9.5.3 Discharge Capacity | Clause removed, see |
| 0 - Clause Removed | 8.2.7 | 9.5.4 Sealing | Clause removed. (Information is repeated in 19.2A ) |
| 0 - Clause Removed | 8.2.8 | 9.5.5 Alternative Materials | Clause removed, see 19.2A . |

| Category | Clause Number (at time of update) | Clause (As of current publication) | Details |
|---|---|---|---|
| 2 - Editing and rearrangement | 8.2 | 8.2 Flashing Design | Completely revised and shortened clause |
| 2 - Editing and rearrangement | 8.2 | 9.1 Penetrations Minimum Pitch | Completely revised and renamed clause. |
| 0 - Clause Removed | 8.3.1 | 9.7.6 Nomenclature | Clause removed. More details added in 19.2A . |
| 0 - Clause Removed | 8.3.2 | 9.7.7 Diverter Or Cricket Designs | Clause removed in favour of more detailed drawings in Penetration Flashing Design. |
| 0 - Clause Removed | 8.3.3 | 9.7.8 Penetration Flashing Installation | Clause removed in favour of more detailed drawings in "Penetration Flashing Design". |
| 0 - Clause Removed | 8.3.4 | 9.7.9 Laps | Clause removed, see 19.2A . |
| 0 - Clause Removed | 8.3.5 | 9.7.10 Details | Clause removed. See 19.2A . |
| 0 - Clause Removed | 8.3.7 | 9.7.11 Type A Soaker | |
| 0 - Clause Removed | 8.3.8 | 9.7.12 Type B Watershed | Clause removed. New Details available. |
| 0 - Clause Removed | 8.3.9 | 9.7.13 Type C Tapered | Clause removed. New flashing details provided. |
| 0 - Clause Removed | 8.3.10 | 9.7.14 Type D Tray | Clause removed. New Flashing details provided elsewhere. |
| 2 - Editing and rearrangement | 8.3 | 8.3 Flashing Cover | Completely revised clause. Drawings updated for clarity. |
| 2 - Editing and rearrangement | 8.3 | 9.5 Penetration Design | Revised clause. |
| 2 - Editing and rearrangement | 8.4.1 | 9.6.2.1 Plant Room And Conduit Penetrations | Completely revised clause. |
| 2 - Editing and rearrangement | 8.4 | 8.3.2 Flashing Edges | Completely revised clause. Drawings updated. |
| 2 - Editing and rearrangement | 8.5.1 | 8.4.1 Ridge And Hip | Completely revised clause. |
| 2 - Editing and rearrangement | 8.5.3 | 8.4.3 Parapet Cappings | Completely revised clause. |
| 3 - Substantial change to recommendation | 8.5.4.2 | 8.4.4.2 Change Of Pitch | Completely revised clause. Drawings updated. |
| 0 - Clause Removed | 8.5 | 9.9 Dormer Junctions | Clause removed. |
| 4 - Clause Inserted | 8.7.3 | 8.6.3 Sealant Extrusion And Placement | Updated drawing: "Applying Sealant". |

| Category | Clause Number (at time of update) | Clause (As of current publication) | Details |
|---|---|---|---|
| 4 - Clause Inserted | 8.8.2 | 8.7.2 Notched Edging | New Clause to follow "Soft Edging", under "Profile Closures". |
| 2 - Editing and rearrangement | 8.8 | 8.7 Profile Closures | Completely revised clause. |
| 4 - Clause Inserted | 8.9 | 8.8 Flashing Buckling | Inserted new clause. |
| 4 - Clause Inserted | 8.32 | 19.2 2018 – November | November Update Message added |
| 2 - Editing and rearrangement | 8 | 9 External Moisture Penetrations | Completely revised and renamed clause. |
| 4 - Clause Inserted | 9.3 | 9.2.1 Penetrations Safety | New sub-clause under "Additional Support". |
| 4 - Clause Inserted | 9.5.1 | 9.4 Penetration Positioning | New Clause. |
| 4 - Clause Inserted | 9.5.2 | 9.5.1 Sheetmetal Penetration Flashings | New Clause. |
| 4 - Clause Inserted | 9.5.3 | 9.5.2 Watershed Back Flashings | New Clause |
| 4 - Clause Inserted | 9.5.4 | 9.5.3 Soaker Back Flashings | New Clause |
| 4 - Clause Inserted | 9.5.5 | 9.5.4 Curb Design | New Level 2 Clause. |
| 4 - Clause Inserted | 9.5.5.1 | 9.5.4.1 Level Back Curbs | New level 3 Clause under 19.2A . |
| 4 - Clause Inserted | 9.5.5.2 | 9.5.4.2 Arrowhead Back Curbs | New 3rd level clause under 19.2A . |
| 4 - Clause Inserted | 9.5.5.3 | 9.5.4.3 Cricket Back Curbs | New level 3 Clause under 19.2A . |
| 2 - Editing and rearrangement | 9.5.6 | 9.5.5 Sheetmetal Flashing Drawings | Revised and renamed clause. |
| 4 - Clause Inserted | 9.6.1 | 9.6.1 Boot Flashings to an Over Flashing | New Clause |
| 4 - Clause Inserted | 9.6.2 | 9.6.2 Other Applications for Boot Flashings | New Clause |
| 4 - Clause Inserted | 9.6.2.2 | 9.6.2.2 Mechanical Services | New clause |
| 2 - Editing and rearrangement | 9.6 | 9.6 Boot Flashings | Revised and renamed clause. |
| 4 - Clause Inserted | 9.7 | 9.6.3 Flush Penetrations | New clause |

| Category | Clause Number (at time of update) | Clause (As of current publication) | Details |
|---|---|---|---|
| 2 - Editing and rearrangement | 16.7 | 17.7 Wind and Point Load Testing | |

# 19.3 2018 – October

The NZ Metal Roof and Wall Cladding Code Practice (COP), has been updated effective 1 October 2018.

## Summary of Changes in this Update

In this update there are Category 1 - Minor Errata corrections only, for spelling and grammar - no clauses have been substantially revised, nor any recommendations altered.

## 19.3A Revision Detail - 2018 - October

| Category | Clause Number (at time of update) | Clause (As of current publication) | Details |
|---|---|---|---|
| 1 - Minor Errata | 1.5.1 | 1.5.1 Mediation | 1. Inserted "a" before settlement. 2.Corrected spelling of "available" in the second paragraph. |
| 1 - Minor Errata | 2.1 | 2.1 Definitions | General tidy up; Fix spelling: Intersection, surface, heights, dewpoint, six-sided, practitioners, seashore, rainwater, coatings, trademark, components, electromagnetic, skylight, sawtooth, embedded, cross-section, violently, stop end, fibreglass, change. Changed: Low Pitched 15° to 10°, and Pitch Roof 15° to 10°. Remove some extra spaces. Removed some commas. Inserted comma. Changed "newton" to "Newton". Reworked Pop Rivet definition. Removed semi-colon. UPdated "boot Flashings. |
| 1 - Minor Errata | 3.5.6 | 3.5.6 Section Properties | Moved paragraph: "Symmetrical corrugate or trapezoidal profiles have the advantage of being more easily curved around a radius. Because the ribs are necessarily close together, they have the disadvantage of roof traffic loads having to be spread over two crests or along the purlin line, and they have a lower run-off capacity." |
| 1 - Minor Errata | 3.5.8 | 3.5.8 Continuity | Updated Drawing. Arrows were not displaying correctly. |
| 1 - Minor Errata | 3.6.1 | 3.6.1 Point Load | Removed empty paragraph spacing |
| 1 - Minor Errata | 4.9.3 | 4.9.3 Graffiti Removal | Fixed typo "Grafitti" |
| 1 - Minor Errata | 4.10.3 | 4.10.3 Compatibility Table | Inserted "online" in the description of the online interactive tool. |
| 1 - Minor Errata | 4.11.6 | 4.11.6 Capillary Action | Typo — Changed 80 to 8°. |

| | | |
|---|---|---|
| 1 - Minor 4.11.8 Errata | 4.11.8 Microcracking | Replaced drawings a through to e |
| 1 - Minor 5.7 Errata | 5.7 Downpipes | Replaced drawing "Collecting Rainwater" |
| 1 - Minor 6 Errata | 6 External Moisture Overview | Fixed typo: "conductionand" to "conduction and" |
| 1 - Minor 9.3.3 Errata | 10.5.1 Cold Roofs | fixed typo: inserted " is ..." |
| 1 - Minor 9.5 Errata | 10.7 Underlay | 1. Added new new photo – 9.5C Condensation on Synthetic Underlay. 2. Typo: corrected spelling of 9.5B "Condesation.." to "Condensation" |
| 1 - Minor 9.5.5 Errata | 10.7.5 Non-Residential Buildings | Fixed typo: deleted extra "in" |
| 1 - Minor 10 Errata | 11 Natural Light | Fixed typos: "thermal", "installation" and "available" |
| 1 - Minor 10.1 Errata | 11.1 Clause G7 NZBC | Fixed typos: "through", "enough" |
| 1 - Minor 10.2 Errata | 11.2 Materials | Fixed typos: "a varying mass" and "square" |
| 1 - Minor 10.3 Errata | 11.3 Types Of Roof Lights | Fixed typos: "single" and removed extra space after comma. |
| 1 - Minor 10.5 Errata | 11.5 Weathering And Durability | Fixed typo: "not" |
| 1 - Minor 13.1.2 Errata | 14.1.2 Turn-Downs (Drip Forming or Drip Edging) | changed "downturns" to "Turn-downs" and inserted "drip forming or drip edging" in the heading. |
| 1 - Minor 13.3.3 Errata | 14.3.3 Screws | 1. Fixed typos: "hardwoods", 2. Fixed broken links" "Fastener Performance" and "Secret Fixing Clips" |
| 1 - Minor 13.5.3 Errata | 14.5.3 Expansion Fixings | Fixed link: "favourable conditions for expansion" |
| 1 - Minor 14.1.5 Errata | 15.1.5 Purlin Spacing | Fixed typo: "subjected", removed comma. |
| 1 - Minor 14.4.2.4 Errata | 15.4.2.4 Types Of Joints | Removed unnecessary link: (See drawing 11.2.4) |
| 1 - Minor 16.1.3 Errata | 17.1.3 Resistance for wind pressures | Replaced incorrect numbering reference (section 15.7) with correct link (Wind and Point Load Testing) |

| | | |
|---|---|---|
| 1 - Minor 16.2 Errata | 17.2 Commentary On Part 16.1 | Corrected heading "Commentary on 16.1" |
| 1 - Minor 16.4 Errata | 17.4 Commentary On 16.3 | Corrected heading: "Commentary On 16.3" |
| 1 - Minor 16.9 Errata | 17.9 Commentary On Section 16.6 | Corrected heading: "Commentary On Section 16.6" |