Vulcan® Siding
North America

Design and Installation Guide

New Growth Feature Timbers

ABODO

Introduction

○ Overview

Abodo Vulcan® Siding is a high performance natural exterior siding product made from heat tempered (thermally modified) New Zealand plantation timber.

The thermal modification process enhances stability, reduces resin content, creates a beautiful homogeneous brown color, and is naturally durable so does not require any chemical preservatives (chemical treatment is required for termite zones).

Vulcan Siding – Vertical Grain is laminated with a vertical grain orientation, enhancing the stability of the timber and allowing design possibilities previously unseen with many traditional timber species.

This document pertains to Vulcan Siding (Cladding) – Vertical Grain products.

Design Scope

This document is suitable for use as an indicative guide for design, coatings and installation of Abodo® facade products in above ground exterior applications including siding, rain screens and soffits.

This document is not an exhaustive list of requirements. It must be read in conjunction with local building codes and standards, certification body requirements, distributor installation documentation and project-specific architectural specifications, along with the latest Abodo Technical Data Sheets.

Prior to design and construction ensure compliance with specific local building regulations and consider specific site conditions.

Always consult with your local Abodo distributor for the most current and comprehensive installation information.

This Design Guide is intended for use in the North American market only. All other markets aside from New Zealand and Australia refer to the Abodo Vulcan Cladding Design and Installation Guide.

Vulcan timber is suitable for all climates, although local weather conditions play a significant role in shaping the aesthetics of a facade over time. Sun exposure, humidity, rainfall, wind, snow, and hail are the primary factors influencing the weathering process; and will contribute to the natural aging of exposed timber.

Vulcan thermally modified timber is not naturally resistant to termites, so must be treated for use in termite zones. Abodo offers well tested treatment options for these locations.

Product

Name	Abodo Vulcan Siding – Vertical Grain
Grade	Select (refer to Abodo Appearance Grading Rules)
Species	New Zealand Radiata Pine
Treatment	Thermally modified 446°F/230°C
Durability	Class 1 (EN350-1)

Certification	Forest Stewardship Council® (FSC®) Certified FSC MIX, SGS-COC-004944
Moisture Content	Approx. 7% MC (+/-2%) at time of dispatch. Moisture content may vary depending on environment
Interior VOC	CDPH Standard Method V1.1-2010 compliant
Environmental	ILFI Declare Certified – Red list free
Average Density	26 lb/ft3 (420 kg/m^3)

Hardness	Low (561 lbf)
pH (Indicative)	3.9
Thermal Performance	0.055 BTU/(hr·ft·°F) (0.095 W/(mK))
Fire	Class C (ASTM E84); Wildland Urban Interface (WUI) SFM 12-7A-1
Warranty	25 years against fungal decay (subject to pro-rated warranty terms)

Scope of Use

Siding (Cladding), rain screens and soffits in above ground exterior application. Interior linings, walls and ceilings.

Product Handling and Storage

- Siding and accessories must be kept clean, dry, well-ventilated, under cover and out of the weather prior to installation.
- If moisture content is higher than 14%, measures must be taken to allow the product to dry before installation.
- Timber must be stored horizontally on bearers at least 6" off the ground in a well-ventilated area.
- Extra care must be taken during installation so as not to damage the factory finish of the boards.
- Wear a dust mask and eye protection when cutting timber.
- Wear cotton gloves when handling or installing the timber to avoid dirty/oily hand marks appearing post installation.
- Timber waste may be disposed of by reuse, landfill, mulch or incineration.
- If water has made its way into the pack, the wood must be dried before use. Open the timber pack and remove the packaging. Sticker the wood. Place under cover in a well ventilated area to dry. Wood that has warped should be discarded.
- Check the moisture content and the surface moisture content before the wood is to be used.

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Design Considerations

Design Detailing

Prior to design and construction ensure compliance with specific local building regulations and consider specific site conditions.

The external siding assembly is positioned in the wet zone of the external wall.

Siding is installed over a drained and ventilated cavity, vented at both the top and bottom.

When designing siding systems always consider the 'Four D's':

- **Deflection:** Ensure water is deflected away from the critical junctions in the siding.
- **Drainage:** Allow any water that penetrates the exterior siding to be drained back out of the wall assembly.
- **Drying:** Not all water will drain within a wall assembly therefore water must be allowed to drain off the face of the building.
- **Durability:** All components of the wall assembly must be of suitable durability for the local conditions and building code requirements.

Environment

Environment is without a doubt the most critical factor when designing timber exteriors. The extent of exposure to weather will dictate the life and condition of timber. Ultraviolet (UV) rays and driving rain cause weathering of exterior timber.

Different geographical zones have different challenges.
In general, North Eastern states and Canada have freezing temperatures. Pacific North West and British Columbia have high rainfall. Central states are characterized by arid conditions with high sunshine hours and low humidity, Southern US states have higher humidity and rainfall, combined with termite risk.

○ Vodafone Christchurch – Vulcan Siding in Protector – Teak. Designed for easy maintenance.

Eaves

In exposed applications larger soffits will protect timber siding and joinery elements from rain and reduce the amount of UV exposure.

Orientation

Using timber components that are less exposed to the prevailing weather will reduce the maintenance required and increase the timber's lifespan.

Northern Hemisphere

Generally southern and western orientations receive the maximum weather, shelter these areas where possible.

○ Shown here – Western Red Cedar. South facing dark color fading and uneven erosion due to grain orientation.

Prevailing Winds

Strong prevailing winds, particularly on coastal sites can blow sand and other abrasive substances onto timber facades causing surface damage. Design to shelter exterior timbers from these conditions.

Wood Weathering

All wood when exposed to the weather if left uncoated or clear coated will change to silver grey eventually. For thermally modified timber this lightening process will happen more rapidly than many other traditional timbers. Some surface checking (cracking) and dimensional movement can be expected as part of the weathering process. Application of a coating will enhance the aesthetic performance of the wood over time.

Where a natural brown color is desired, a translucent brown pigmented coating should be used. By using darker wood finishes, maintenance requirements by way of re-coat period will generally increase. Highly exposed orientations should be designed for easy access for re-coat.

On exposed high elevations, choose wood coatings that are more durable, such as paint finish, reactive or silvering erosion stains. Lighter colors and shades of grey allow the timber to age gracefully in highly exposed applications so are preferable here.

See coatings section for more information.

○ Uneven weathering of uncoated Western Red Cedar.

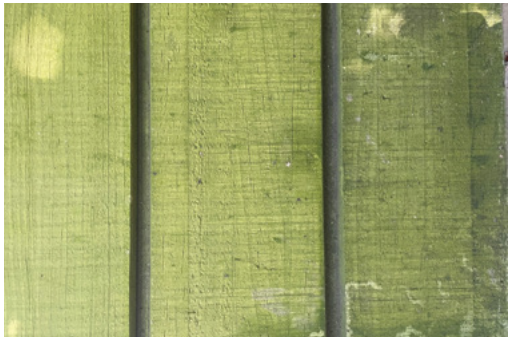
Moisture Humidity and Mold

Fungal decay and mold are the enemy of exterior wood. Though quite different things, both fungal decay and mold thrive in warmer, wet environments that are rich in plant life.

Mold

In many cases a black discoloration referred to as mold can affect exterior timbers. This discoloration can affect new or weathered wood and is generally caused by a black form of yeast fungus identified as Aureobasidium or Hormonema, although there are many other different types.

○ Surface mold (black mold) – Larch.



○ Surface mold (green algae) – Radiata Pine.

Mold growth is distinct from fungal decay in that mold is a purely aesthetic issue, whereas fungal attack can cause damage to the wood leading to structural failure of the product. These organisms live on the natural sugars present in wood, as well as the breakdown products through delignification. Typically, such surface yeasts require exposure to moisture and sun to grow.

It is recommended to choose coatings that contain moldicides to reduce mold growth particularly in wetter applications. If it is not removed early on in its growth, mold can set into the timber, become more difficult to clean off and lead to early failure of coatings. Organic based oils such as linseed oil, danish oil, soy oil and lanolin should be used with care as they can provide food for mold fungi.

Mold or algae growth should be cleaned off as soon as it occurs using a wood cleaner. Regular cleaning of the facade and use of a slow release moldicide will help prevent mold growth on-going.

See maintenance section for more information.

○ Installation details are critical

- Detail sufficient ground clearance, ideally 6″ or more above ground level for siding.
- Carefully detail end joints and exposed end grains, these should be detailed with adequate ventilation and protection, and/or sealed with a high solids end seal, to help reduce moisture uptake and reduce decay.
- Drip lines on all exposed vertical siding ends should be created by cutting a 15° miter. This is also known as a ‘weathering cut’.
- Allow minimum 3/8″ clearance to adjacent materials and sloped flashings.
- In humid environments more regular cleaning will be required to prevent mold growth, consider wood cleaners with long-acting biocides such as BAC (benzalkonium chloride).
- Ensure applied coatings have an active moldicide in them.

Plants

Plants and trees located too close to siding can lead to damage to the siding over time as the leaves or branches move in the wind and rub against the timber surface. Trees can also drop leaves in gutters causing blockages and overflow of rainwater, leading to unplanned water ingress into the siding system or discoloration of the surface.

It is important to ensure plants and trees are planted with an appropriate gap to walls and roof lines and that they are maintained regularly by trimming back.

○ Plant damage to walls.

Marine Environments

In many instances timber is a great product for marine environments as it does not rust.

However marine environments have their own specific challenges, namely high UV, salt spray, sand and abrasive winds. Surface erosion or mechanical weathering from wind borne salt and sand, along with plant life can put additional pressure on wood, surface coatings and fasteners.

Timbers should be orientated to minimize exposure and additional details should be considered:

- Concealed fasteners in stainless steel should be considered, even stainless steel and silicon bronze can oxidize and this can create an unsightly stain on exposed timber.
- In marine applications use type 316 stainless steel fasteners from reputable manufacturers.
- More durable coating systems should be considered including acrylic paints, or low maintenance natural wood finishes such as grey erosion stains. Acrylic paints should be less than 39% solids and applied over an alkyd based primer.
- Acrylic paints must be maintained, as flaking may cause moisture entrapment, eventually leading to premature decay.

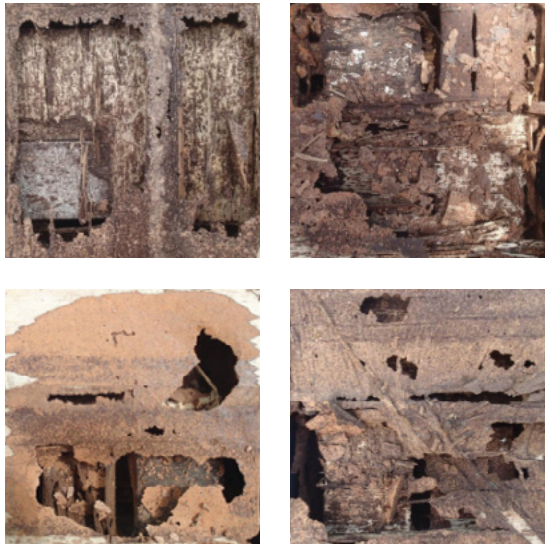
Insect Attack

Termites

Certain geographical zones have wood destroying termites. Termites are known to do severe damage to wood. Termites often burrow into the timber, eating the wood from the inside out, often serious damage is done before anyone is aware. As Vulcan is not termite resistant, a preservative treatment system must be used.

Particular care must be taken to apply an end seal containing appropriate termiticide chemical. Use of termite barriers around the base of the building and/or entry points should also be considered. Design should allow for a full visual inspection around the perimeter of the building.

Abodo offers a number of termite treatment options depending on the geographical location. Please check with an Abodo distributor for the most suitable treatment options.



○ Internal termite damage – untreated Pine.

Paper Wasps and Other Scraping Insects

Paper Wasps and other insects such as Carpenter Bees can be known to create superficial damage to timber siding and coatings. This can appear to be a failing of the timber coating, but it is often the result of scraping from insects or small holes. In particular the Asian, Chinese or Japanese Paper Wasp and their subspecies.

Paper Wasps build nests around houses. By scraping and chewing wood into a workable pulp, Paper Wasps make paper type nests in the shape of an umbrella for protection – they literally make paper – hence the namesake.

These nests are typically constructed in protected locations including in bushes, trees, ceilings, window and door frames, roof overhangs, and under decks or joists. The queen deposits eggs in the comb on the underside of the nest.

○ Paper Wasp damage.

Few softwood timbers appear to be immune from Paper Wasp attack, and although they are unlikely to make any structural damage to the timber, the result is unsightly.

Paper Wasp attack is very difficult to stop – it is nature at its best. Some results have been achieved by mixing insecticides into the coating to provide some repellency.

Spraying an insecticide on top of the siding may provide some temporary protection, but this will eventually be washed off the surface of the wood.

Film forming or high build surface coatings can also help prevent surface grazing from Paper Wasps.

Fire

Wood has good thermal insulation properties, high structural strength and a slow charring rate, so its general behavior in a fire situation is fairly predictable.

Vulcan timber has been tested and conforms to Class C (ASTM E84); Wildland Urban Interface (WUI) SFM 12-7A-1 – note design and installation of the siding system must be in accordance with relevant test report documentation and local building code requirements. Specific profiles and installation details may apply. Please enquire with Abodo prior to specification.

Abodo's tested WUI SFM 12-7A-1 system requires Vulcan Tongue and Groove (T&G) siding to be fixed over Wrapshield RS Rainscreen 3mm ventilation mat over 5/8" thick FlamePro Ply wood sheathing.

In areas where the consequence of fire is greater, for example in public buildings such as cinemas, theaters, libraries, schools, offices, hotels, hospitals and bush fire zones, building regulations are in place governing the use of performance rated, flame retardant building products.

Flame Retardants (FR) generally work by reducing the surface spread of flame, heat and smoke release, providing vital extra time for a safe escape.

Where building regulations or fire assessments stipulate a need for fire protection of timber siding, we recommend pre-treatment with a quality assured pressure impregnated, leach resistant flame retardant applied by a processor approved by the product manufacturer.

Abodo offers Vaaro® fire retardant treated timber that conforms to Class A (ASTM E84).

Fire systems are outside the scope of this guide. Please check with the distributor for available FR treatment and project specific requirements prior to specification and installation.

Always seek advice from a qualified fire engineer and adhere to up-to-date national guidance on fire regulations and standards.

Dimensional Movement

Wood is hygroscopic, meaning its moisture content is affected by changes in temperature and relative humidity of the surrounding environment. This results in movement across the grain of the timber.

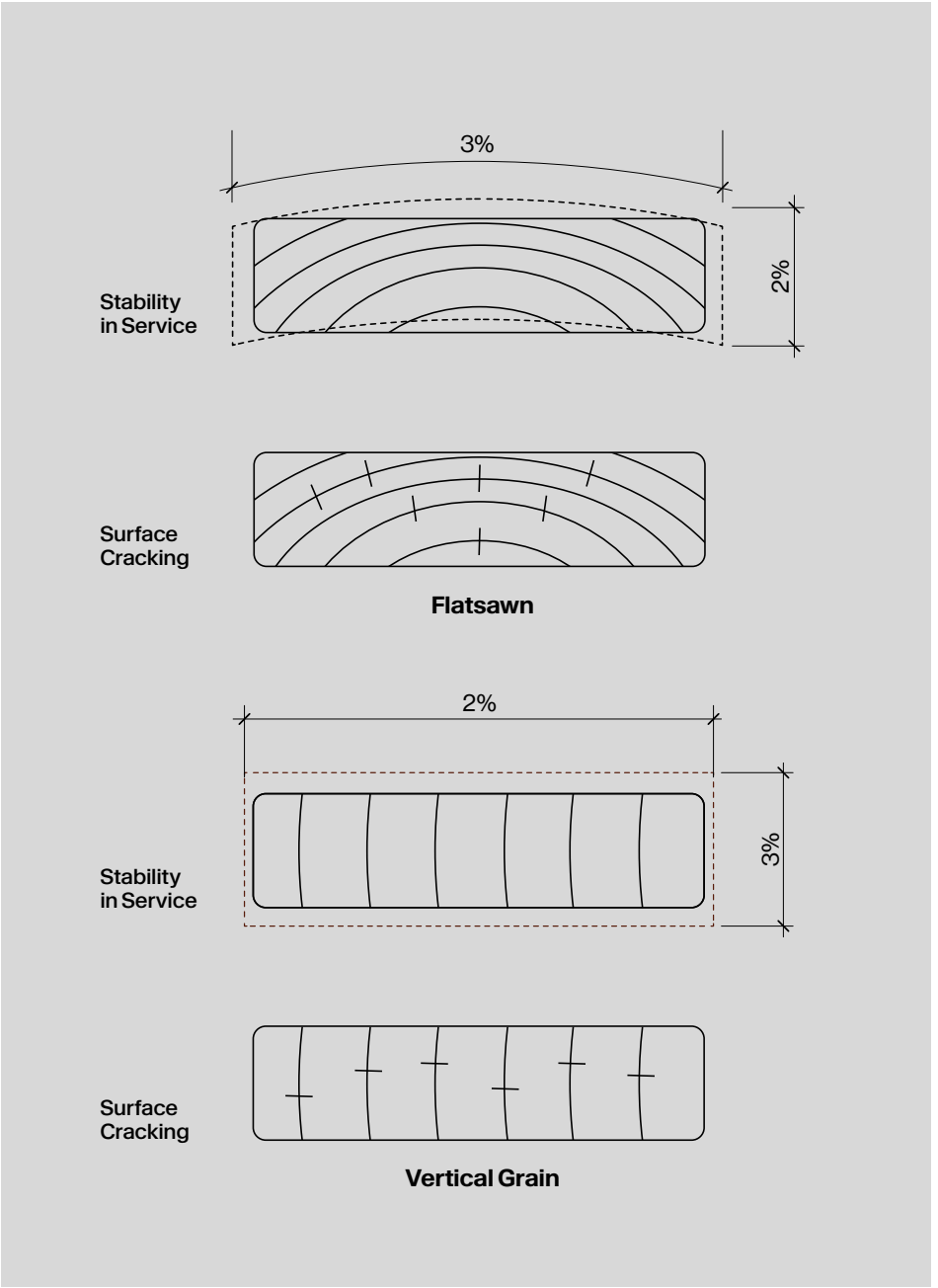
Variation in timber moisture content, density and grain orientation can influence the amount of movement in service. Shrinkage may result in siding boards pulling apart and becoming unstable or exposing uncoated timber on siding that has been painted or stained after installation.

Expansion coupled with inadequate movement gaps during installation can result in boards bowing or pulling away from their fasteners.

Vulcan is classified as a 'small' movement timber. The thermal modification process results in a physical change to the timber and significant lowering of the equilibrium moisture content (EMC) compared with regular kiln dried timber. This reduces the ability for the wood to expand and contract in service.

It can be expected that Vulcan timber will expand when wet by approximately 3% tangentially (parallel to growth rings) and 2% radially (perpendicular to growth rings).

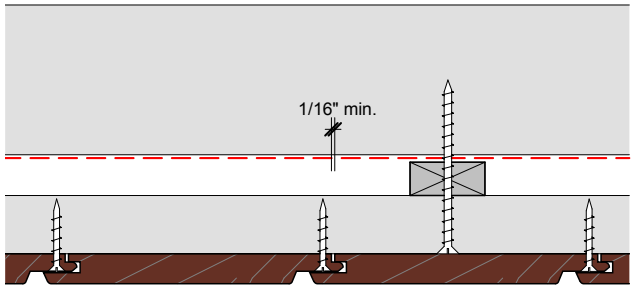
It is recommended that siding is designed and installed to allow for an expansion gap between boards. The expansion gap will vary depending on the width of boards.



○ Natural stability of Vulcan Vertical Grain timber – grain orientation.

Generally, a minimum of at least 1/16" gap should be left between edges at the back face of T&G or shiplap boards in closed joint siding, or 3/16" to 3/8" between the board edges of open joint siding.

Siding should always be kept dry prior to installation and installed at the supplied moisture content to ensure dimensional correctness and uniformity.



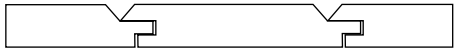
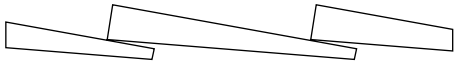
○ Install with expansion gap between edges.

○ Boards bowing or pulling away from their fasteners.

Profile Design

Vulcan timber can be machined into a wide array of profiles to suit a wide array of design aesthetics. The below represents the main siding types.

Dimensions and styles can vary between suppliers. Please check with your local distributor for their standard offer and associated specific fixing instructions.

Profile type	Siding joint	Recommended orientation			Typical board width	Minimum thickness
		Horizontal	Vertical	Diagonal		
Shiplap 	Closed	✓	✓	✓	3.5″ - 7″	11/16″
Tongue and Groove (T&G) 	Closed	✓	✓	✓	3.5″ - 7″	11/16″
Bevelled/Feather edge 	Closed	✓			5 1/2″	Thin end minimum 3/8″. Thick end 5/8″ - 1″
Batten 	Open (Closed for board-on-board design)		✓		2 1/2″ - 7″	11/16″
Rhombus 	Open	✓	✓		2 1/2″ - 7″	11/16″

○ Siding profile design tips

- Horizontal profiles should be designed with a bevelled edge to shed water.
- Paint or film-forming coated profiles must have 1/16″ to 1/8″ eased edged radius to reduce stress on the coating in service, film forming coatings are normally suited to a smooth face finish.
- A textured, bandsawn or brushed face is recommended for stain-coated siding profiles.
- A minimum 1/16″ expansion gap should be allowed for in T&G and shiplap profiles to accommodate dimensional change when wet.
- Minimum 3/4″ overlap is recommended to all closed in siding profiles, aside from T&G that may be 3/8″.
- 5/16″ - 3/8″ edge gap is recommended between open joint siding profiles.

Installation

Wall Build-up – Ventilated Cavities

The fundamental aspects of installing siding can be broken down as follows:

- The external siding assembly is in the wet zone of the external wall.
- Siding is fitted over a drained and ventilated cavity, vented top and bottom.
- A weather resistant barrier (WRB) separates dry and wet zones.

Framing

Timber framing must comply with relevant local standards and building regulations. In general timber should be of a structural grade and kiln dried to maximum 14% moisture content.

Steel framing or masonry may also be used according to manufacturer's specification and local building regulations.

Insulation

To achieve a required thermal performance, it might be necessary to add an insulation layer to the outer face of the backing wall but behind the timber siding assembly.

- The insulation should be either: rigid, fixed to the backing wall and able to carry the siding battens directly or be carried within a framework of timber battens or I-joists in a double layer arrangement to prevent thermal bridging.
- The insulation layer should be no more than 4" thick unless the support assembly is designed to take lateral loads.
- If used, insulation should be securely fastened and properly supported.
- Joints between adjacent pieces of insulation should be tight, with no gaps greater than 3/16" wide.

Sheathing

Sheathing is a rigid sheet material fixed to a frame and will provide racking resistance against lateral loads such as wind.

If placed in a wet zone, the sheathing must be water-resistant.

The thickness of the sheathing generally ranges from 3/8" to 3/4", depending on the expected lateral loads.

OSB3 (oriented strand board) may be used as sheathing, though water-resistant plywood or fibre cement can also be used.

Consult with manufacturer's specifications and instructions for correct install details.

Weather Resistant Barriers (WRB)

Siding must be installed over a waterproof, vapor-permeable weather resistant barrier, or over an appropriate waterproof substrate such as concrete or masonry.

When using concrete or masonry, a membrane is normally not necessary.

If a weather resistant barrier is used, it should be vapor-permeable with a perm rating between 0.4 and 0.9 perms (equivalent to 0.25–0.6 MN·s/g). All WRB overlaps should be at least 2 inches (5 cm) horizontally and 4 inches (10 cm) vertically.

For open joint siding systems (such as rainscreens or rhombus/parallelogram profiles), a UV-resistant WRB is required to prevent degradation from sun exposure.

Install a self-sealing nail point tape made of butyl or closed-cell polyethylene between battens and breather layer to ensure that the membranes are completely sealed at the points where support battens screws pass through the membrane.

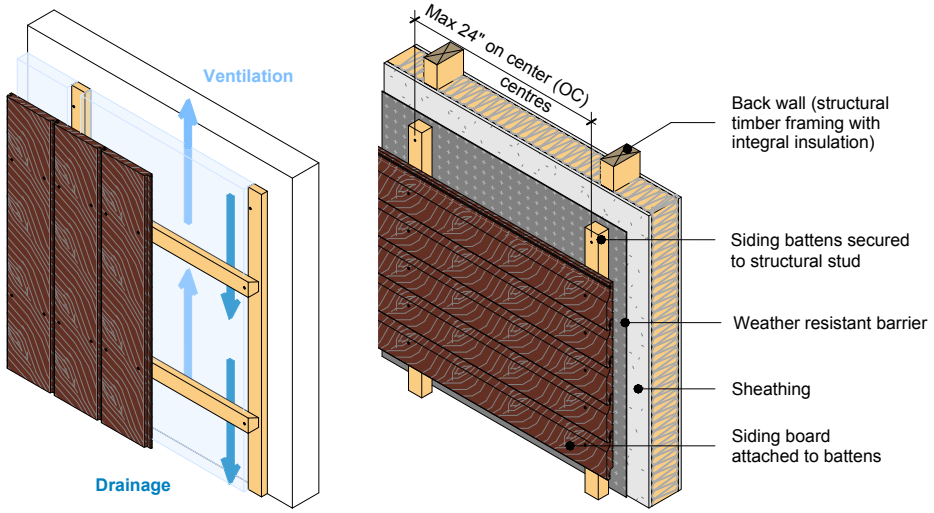
Cavities

Timber siding provides a form of weather protection. But not all wind driven rain will be deflected, so a well-ventilated, free draining cavity should always be included in the detailed design.

Open at the top and bottom to allow through ventilation, a cavity channels any moisture that might enter, back to the building's exterior. By using a series of timber battens, a cavity between the siding and the backing wall structure can be created.

- A minimum 3/8" (10 mm) air gap is required for effective ventilation, though actual depth will depend on the thickness and orientation of the siding support battens. Use vertical or horizontal furring strips (battens) to create the cavity between the siding and the structural wall or sheathing.
- Install insect-resistant mesh at all ventilation openings to prevent access by birds, rodents, and larger insects. Note: very small insects may still enter.
- At ground level and other vulnerable areas, metal vermin mesh should be used for closed joint systems to block small animals.

○ Drainage and Ventilation



Cavity Battens

Timber siding must be fixed to timber battens (also known as furring strips or siding battens), which are secured to the backing wall, creating a drained and ventilated cavity. This cavity separates the outer siding from the structural substrate, allowing for effective moisture control and ventilation.

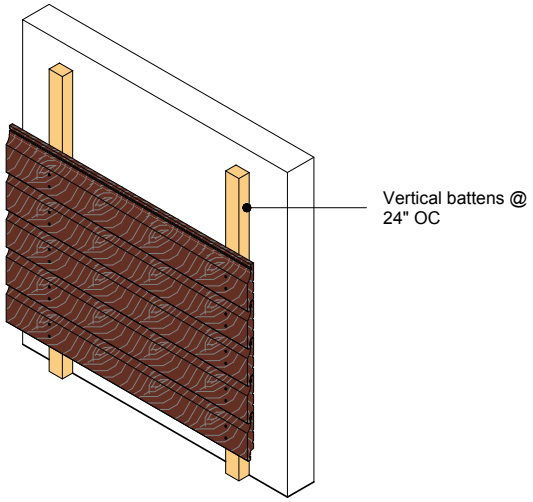
Timber cavity battens must be made from minimum UC3B pressure-treated kiln dried softwood, or minimum natural Durability Class 2 (EN350-1) structurally graded timber to ensure durability and resistance to decay. Vulcan thermally modified timber battens may also be used for this purpose.

An alternative to a wholly timber batten support assembly is a proprietary metal framework or timber support battens carried on metal brackets. In both instances, the installation can be designed by the framework/bracket supplier. Steel must have suitable durability and performance specifications for exterior structural use.

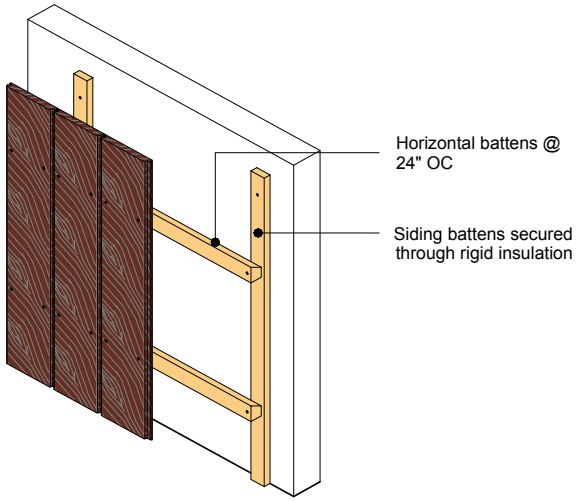
Horizontal siding is fixed to vertical battens allowing water to run off easily and promoting airflow behind the siding.

Vertical siding is fixed to horizontal battens with a 10-15° angle applied to the top to shed water. Since horizontal battens can obstruct water drainage and ventilation, vertical counter-battens are installed behind them to create a gap for moisture control and airflow.

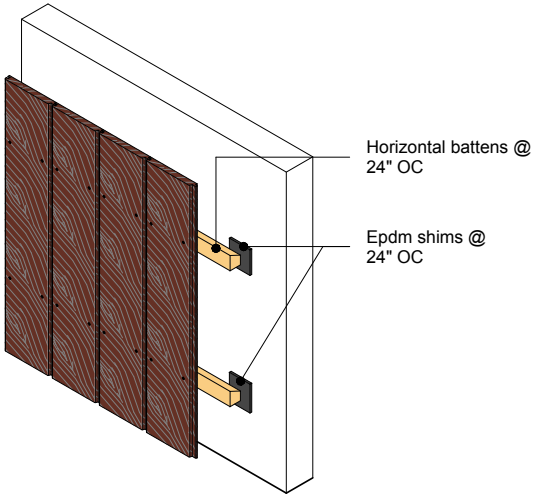
○ Horizontal Siding – Vertical Battens



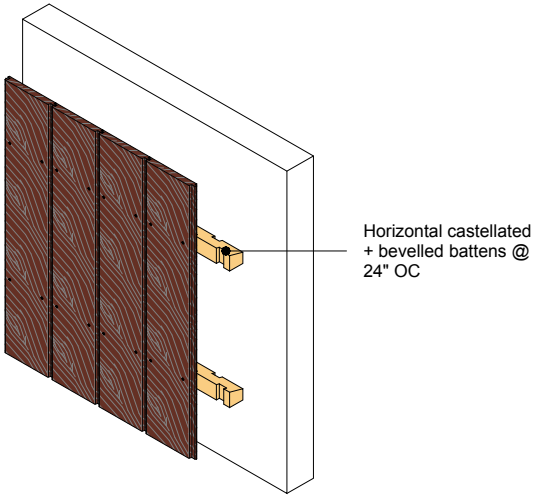
○ Vertical Siding – Horizontal and Counter Battens



○ Vertical Siding – Horizontal Battens and EPDM Shims



○ Vertical Siding – Horizontal Castellated Battens



Alternatively, EPDM (Ethylene Propylene Diene Monomer) rubber shims with a minimum thickness of 1/4" (approx. 6mm) may be used at each batten fastening point in place of continuous vertical battens to create the required drainage and ventilation cavity.

An alternative method may use a proprietary castellated and bevelled horizontal cavity batten with grooves machined into the face and back of the batten. This type of cavity batten allows movement of air and moisture through the cavity without the need for a vertical counter-batten.

Grooves (castellations) must be at least 3/16" deep and approx. 3/4" wide, spaced at approx. 4" centers and offset on both sides of the batten. This configuration should provide a minimum ventilation area of 1.55 in^2 per linear foot (1000mm^2 per lineal meter). The top edge of the batten must be beveled at a 10-15° angle to allow water to shed away from the wall assembly.

○ 1-3/4" x 1-3/4" horizontal castellated cavity batten.

○ Drainage Mat – Alternative Method

Optionally, a drainage mat system such as Vaproshield WrapShield RS Rainscreen (or equivalent) with minimum 1/8" (3mm) thickness may be used in place of cavity battens. Such mats are most suitable in dry or arid climate zones. While drainage mats can be used in more temperate climates, consider assemblies that enable a minimum 3/8" air gap before relying on a drainage mat.

The drainage mat is a lightweight, hydrophobic polyester filter fabric with an attached polyproplene drainage matrix. It is installed over the weather resistant barrier to create a positive drainage cavity behind siding, promoting rapid drying of the building envelope. Refer to manufacturer's instructions for specification and installation. Note: this construction method is not recommended in areas with high rainfall or humidity.

Attaching Cavity Battens to Sheathing

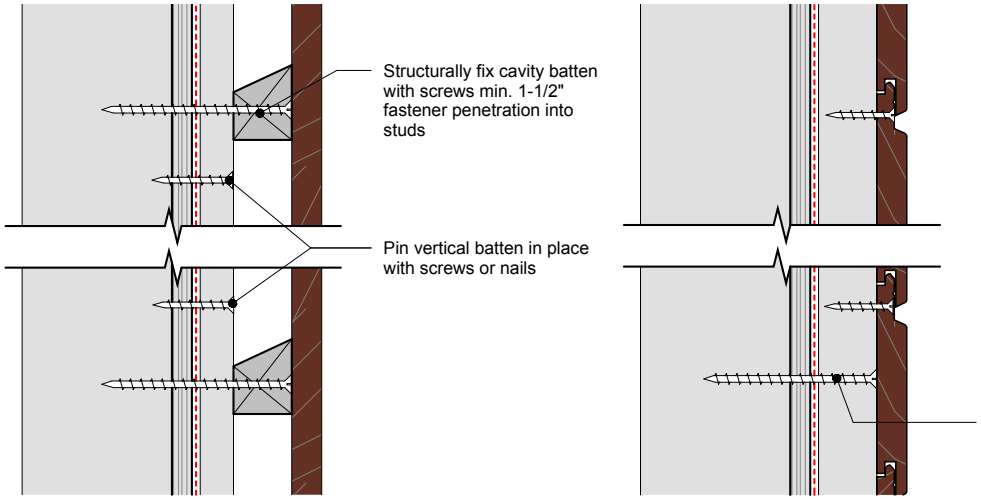
All too often more attention is given to how the siding is attached to the battens when in fact attaching the battens to the wall is more critical, since these are exposed to the full wind load whilst wind loads on the siding layer are generally far lower.

Minimum hot dipped galvanized corrosion resistant fasteners should be used to fix cavity battens. Stainless steel 304 or 316 fasteners must be used in areas near the sea.

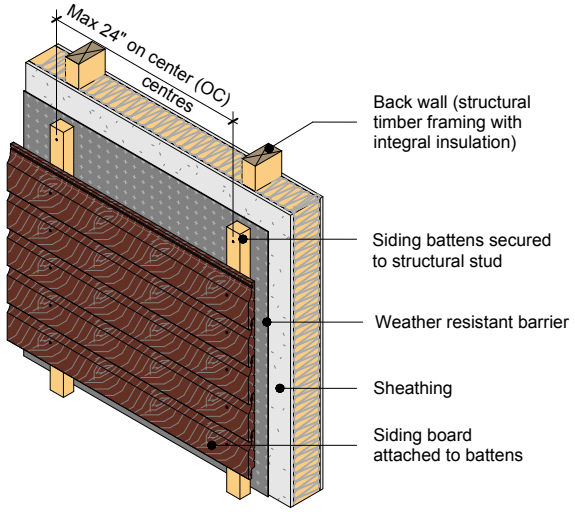
Batten spacing requirements may vary in certain areas depending on wind-loading or engineering requirements. Always check specific batten spacing as required for compliance with local building regulations or site-specific specification documentation.

If the backing wall is masonry, connections between the siding support battens and backing wall need to be designed by a structural engineer.

○ Cavity Batten Fixing



○ Horizontal Siding – Vertical Battens



Vertical wood battens must be at least 11/16" thick x 1-3/4" wide, spaced no more than 24" on center. For diagonal siding installations, reduce spacing to a maximum of 16" on center (OC).

Secure battens directly to framing studs using #10 bugle head screws, staggered along the length of the batten. Screws should be spaced no more than 24" on center and must penetrate the studs by at least 1-1/2" for structural integrity.

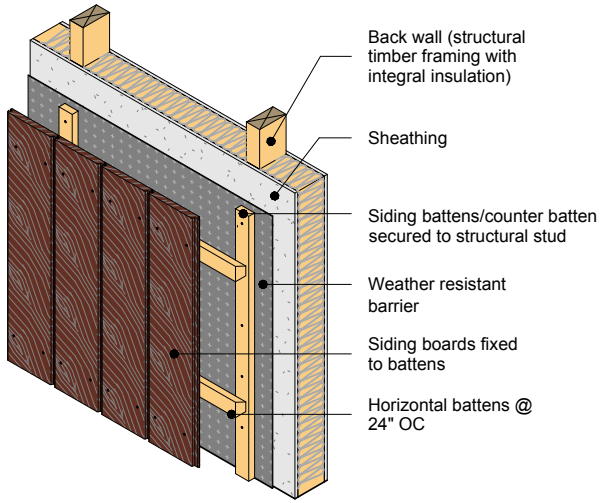
Vertical Siding – Horizontal Battens with Counter-battens

Install vertical wood counter-battens with a minimum size of 3/4″ thick x 1-3/4″ wide, spaced no more than 24″ on center to align with stud spacing. Fasten the counter-battens using corrosion-resistant screws or nails, staggered along the batten at a maximum of 24″ on center.

Shims made from EPDM rubber with minimum 1/4″ thickness at each horizontal batten fixing point may be used in the place of vertical counter-battens.

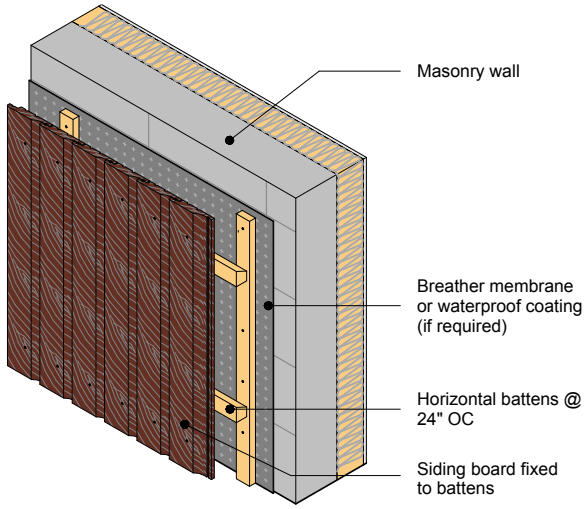
Horizontal battens must have minimum dimensions of 5/4″ thick x 2-3/4″ wide and be spaced at maximum 24″ OC. It is recommended to apply a 10-15° angle to the top of the batten positioning the batten to shed moisture away from the back of the siding and into the cavity. Attach horizontal battens off structurally with #10 screws staggered along the batten at max 24″ OC to match stud spacing through the counter batten/shim with minimum 1-1/2″ fastening penetration into studs.

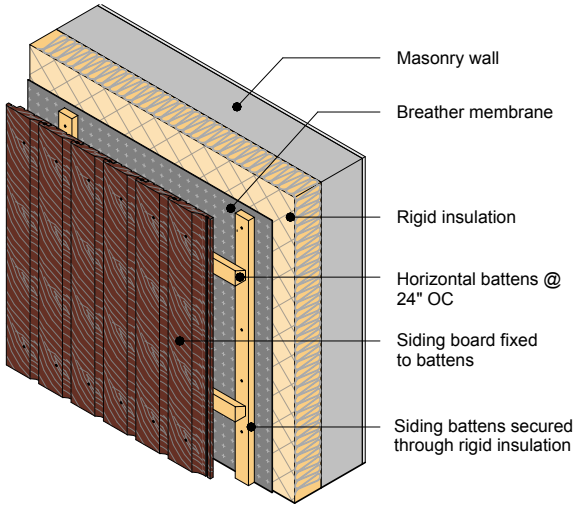
○ Vertical Siding – Horizontal Battens

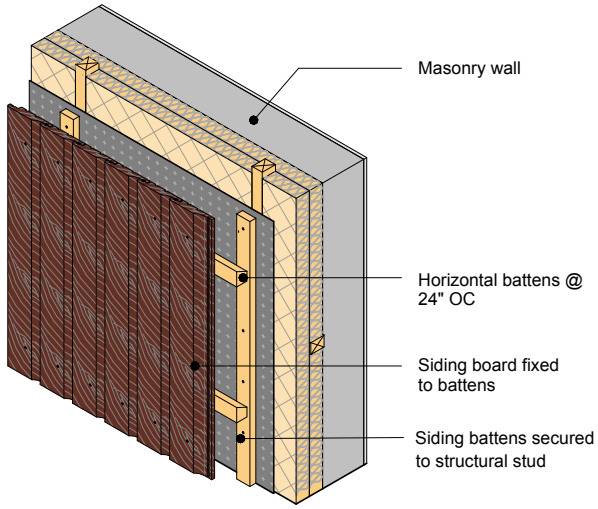


Masonry – Typical Installation

○ Vertical Siding – Masonry







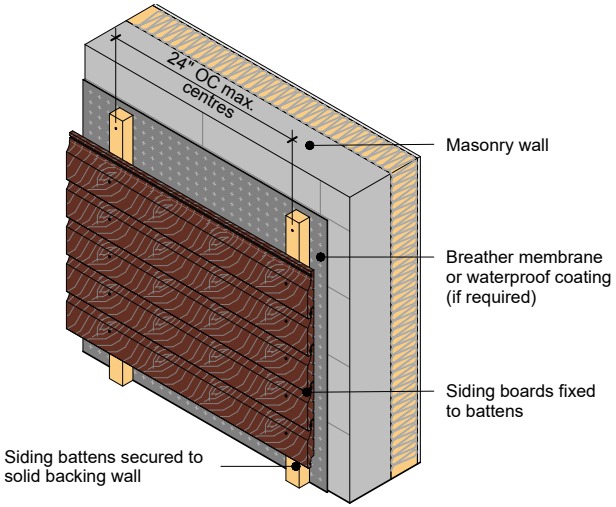
Vertical wood battens must be at least 3/4″ thick x 1-3/4″ wide, and spaced no more than 24″ OC.

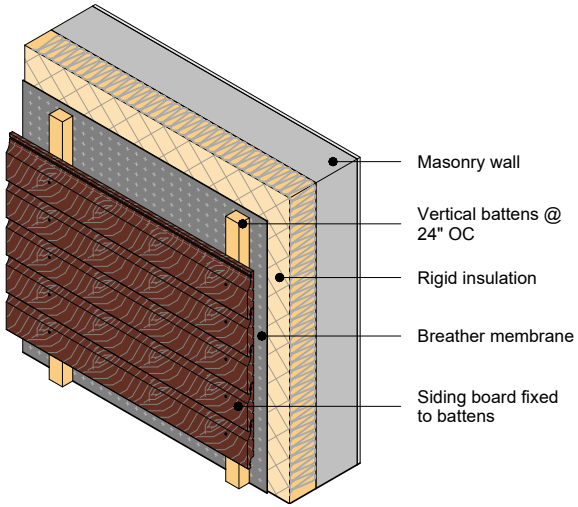
Shims made from EPDM with minimum 1/4″ thickness may be used in the place of vertical counter-battens if appropriate.

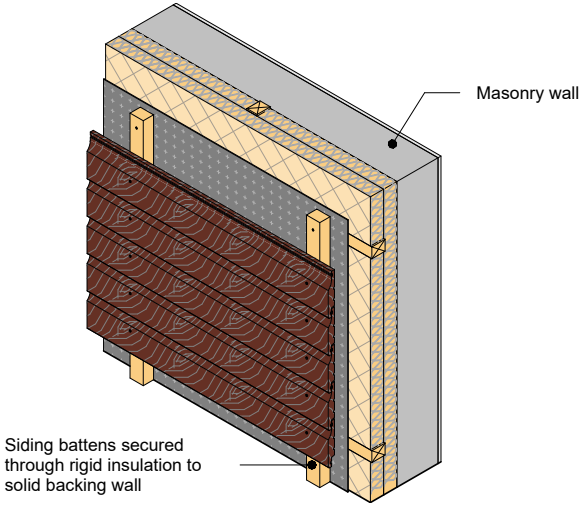
Horizontal battens must have minimum dimensions of 5/4″ thick x 2-3/4″ wide and be spaced at maximum 24″ OC. It is recommended to apply a 15° angle to the top of the batten positioning the batten to shed moisture away from the back of the siding and into the cavity.

Secure horizontal battens structurally by fastening through the vertical counter-battens and into the masonry substrate using staggered masonry anchors. Fastener placement should align with the spacing of the vertical battens. The size, type, and positioning of fasteners must be determined by a qualified engineer based on the specific wall assembly.

Horizontal Siding – Masonry







Vertical timber battens must have minimum dimensions of 1-3/4" thick x 1-3/4" wide (structural battens) and be spaced at maximum 24" OC.

Secure battens directly to masonry using appropriate masonry anchors, staggered along the length of each batten. The size, type, and placement of fasteners must be determined by a qualified engineer based on the specific wall assembly and load requirements.

Fire Cavity Barriers

Minimizing the Risk of Flame Spread

Cavities in the external wall of any building can act as a chimney and provide an easy route for flame, hot gases and smoke to propagate from one compartment of a building to another. Unsealed cavities can allow air to be drawn in and smoke to vent out, enabling the fire spread to accelerate through the facade.

By utilizing carefully selected vertical and horizontal cavity barrier products to sub divide and compartmentalize concealed cavities, the rapid spread of fire from one compartment to another can be prevented. The requirement for cavity barriers is determined by local building regulations and dependant on many factors including type of building.

Tips for creating cavity barriers within a timber siding facade:

- The horizontal cavity barriers must permit vertical through-ventilation except during fires and so can be formed using intumescent strips.

When exposed to high heat, intumescent strips are triggered to expand, closing any gaps to stop the fire spreading for a period of time. They usually come with either 30 or 60 minutes of fire resistance.

- Cavity barriers must be fastened directly to solid construction, they should not just be fastened to the insulation. This might require secondary timber battens within the insulation layer to carry the cavity barriers.
- Attention must also be given to cavities around window and door openings.
- Check manufacturer's specification and installation instructions.

On matters regarding compliance with fire safety, always consult an architect and/or engineer to ensure adherence to current local building regulations.

Installing Siding

For best results we recommend that minimum 304 stainless-steel fasteners are used. However, for hidden fastener profiles – where fastener heads are concealed – or when attaching cavity battens, hot-dipped galvanized fasteners may be used as an alternative to stainless steel.

Stainless steel 316 fasteners must be used in areas near the sea.

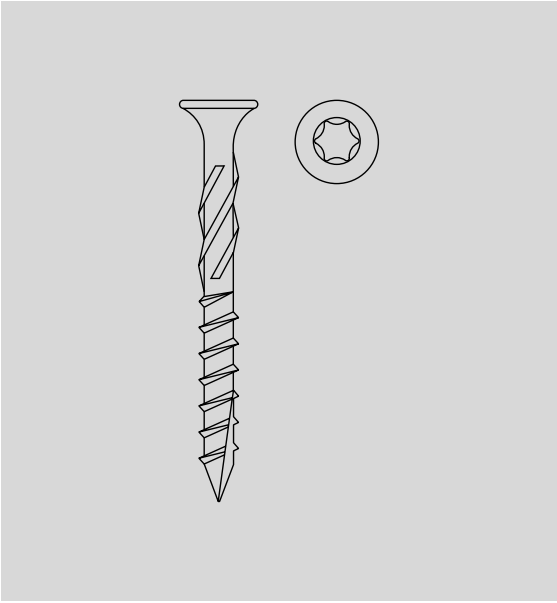
Take care to ensure compatibility of the fastener material with any other materials including flashings or battens that might lead to long term degradation such as galvanic corrosion.

Fastener Type

Use self-drilling, self-countersinking head screws with a minimum diameter of 5/32" (approx. 4 mm), designed for wood-to-wood or wood-to-aluminum fastening, depending on the cavity batten material.

Fastener length should allow for at least 1-1/4" penetration into solid wood battens or framing, or a minimum of three full threads into metal studs or aluminum battens.

Requirements for fastener type and penetration depth may vary depending on local building regulations, site, wind load and specific design requirements. Please check local requirements and project specification prior to construction.



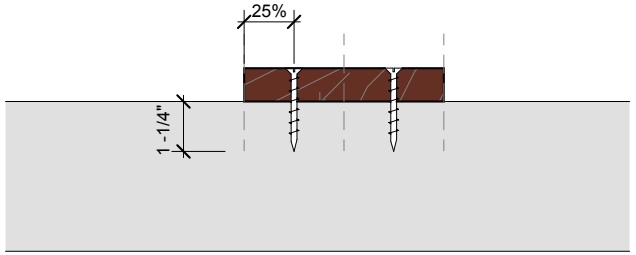
○ Abodo Siding Screw.

Fastener Placement

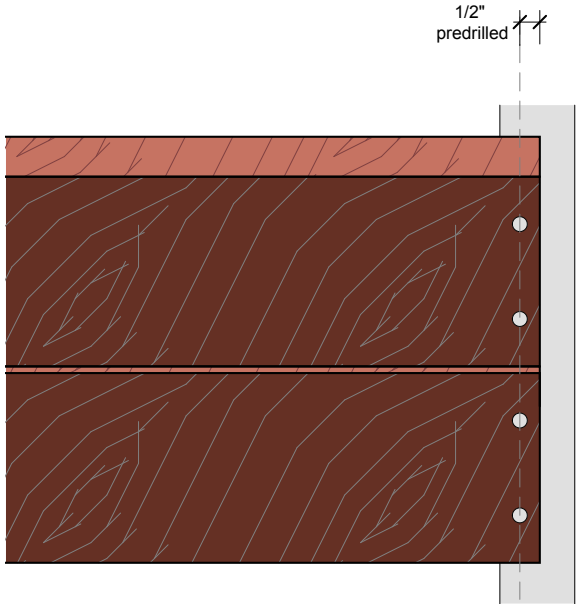
Proper fastener placement significantly reduces the risk of wood splitting and fasteners pulling through the siding boards.

- Face fastening is the most secure method for installing wood siding. Ensure that fasteners are driven flush with the surface of the board without overdriving, to maintain holding strength and prevent damage.
- Use two fasteners at each intersection between the siding board and batten, spaced at approximately one-quarter of the board's width in from each edge. For boards less than 5 1/2" wide (siding) or less than 3" wide (screening), a single centered fastener may be used.
- Place fasteners at least 1/2" from the ends of the boards. For any fasteners located within 2-3/4" of the board ends, pre-drill pilot holes approximately one-third smaller than the fastener diameter to prevent splitting.
- Due to the dimensional stability of Vulcan timber, hidden-fastened T&G siding is possible. Extra care should be made to allow for expansion of timber when wet.
- For closed joint sidings fasteners must be positioned clear of the overlap area. Do not drive fasteners through the lap area under any circumstances.
- Where concealed fastening of rainscreens is required, then boards may be back fixed to counter battens or installed using a proprietary metal fastening bracket or support system. Concealed fastening systems are best used in the prefabrication of siding panels.

○ Fasteners Placed at Quarter Points



○ Minimum 1/2" from Board End



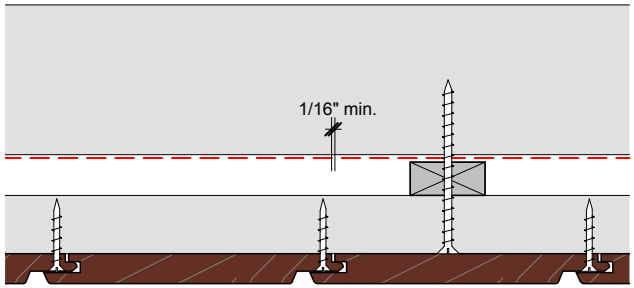
Fixing Vertical Siding

If face fixing, position fasteners 3/4" beyond the overlap (do not fasten through the overlap), driving fasteners so they are flush with the timber surface.

For hidden fastener T&G profiles, position the fastener at least 1/2" from the tongue edge. Drive the fasteners so they are flush with the timber surface.

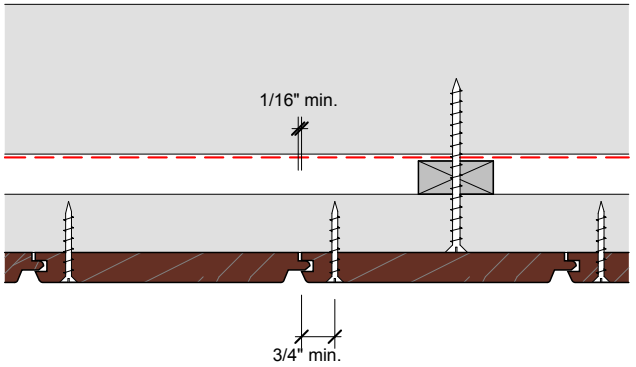
Ensure minimum 1/16" expansion gap to back of boards.

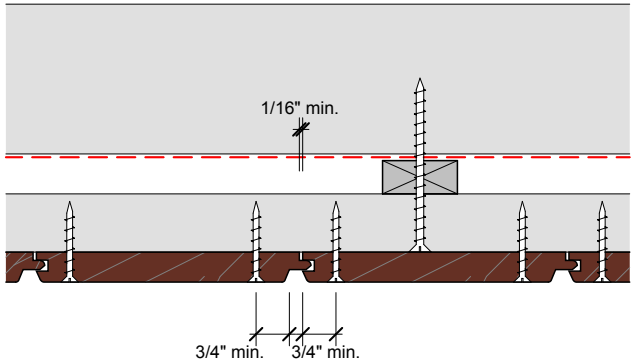
○ T&G Siding – Hidden Fixed



○ Vertical Grain Profiles <8" width may be fixed with a single screw.

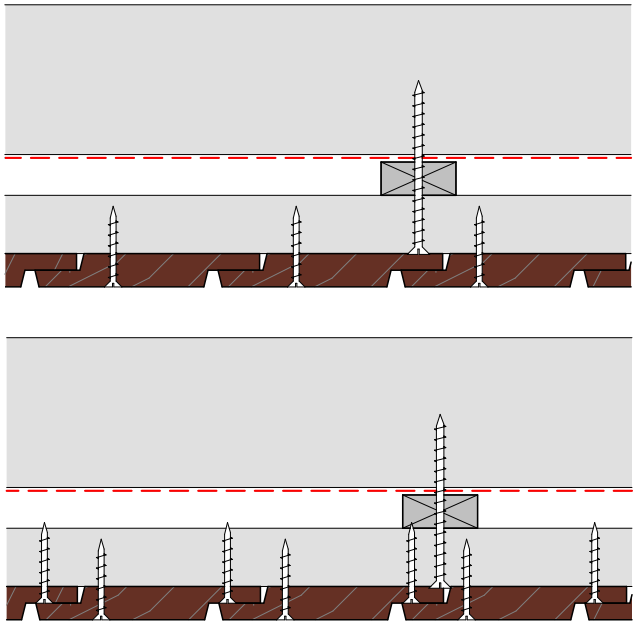
○ T&G Siding – Face Fixed





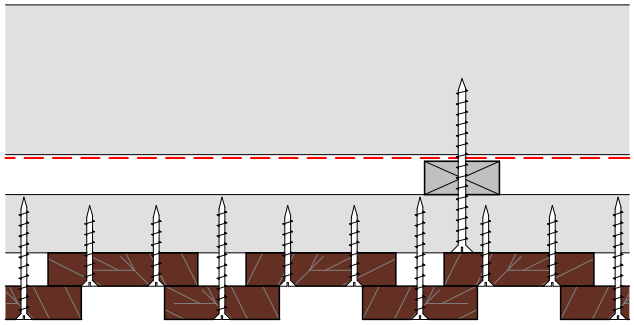
○ Profiles <5-1/2" width may be fixed with a single screw.

○ Shiplap Siding – Face Fixed



○ Profiles <5-1/2" width may be fixed with a single screw.

○ Board on Board Siding – Face Fixed



○ Profiles <5-1/2" width may be fixed with a single screw.

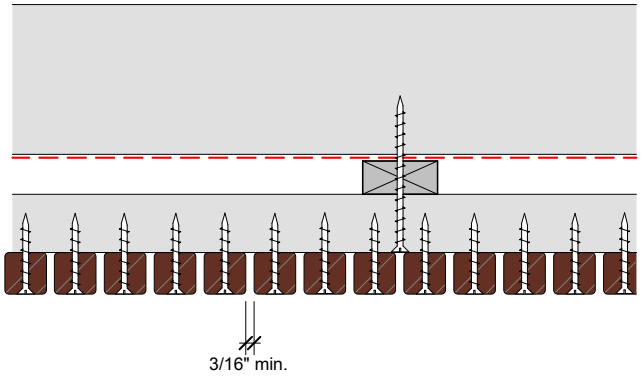
Vertical Rainscreen

Face Fixed

Position fasteners 3/4" from board edges, drive fasteners so they are flush with the timber surface.

Ensure minimum 5/16" expansion gap to edge of boards.

○ Open Joint Rainscreen – Face Fixed



○ Profiles <3" width may have one fastener, profiles >3" width must have two fasteners.

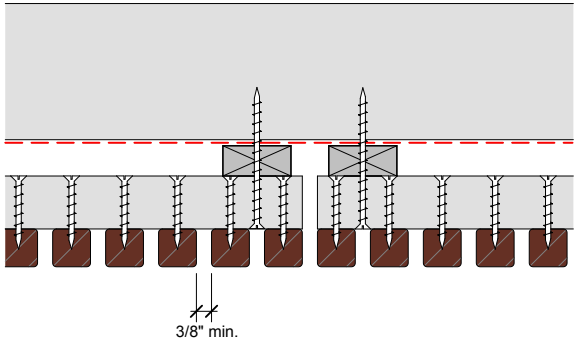
Back Fixed – Panelized System

Screening may be back fixed through horizontal cavity battens to form prefabricated panels. The panels are then screw fastened between the screening edges to minimum 1-3/8″ x 1-3/4″ structurally secured vertical counter battens.

A minimum screening thickness of 1″ is required to allow minimum 3/4″ fastener depth.

Ensure minimum 3/8″ gap to edge of boards to allow securing of cavity battens.

○ Open Joint Rainscreen – Back Fixed



○ Profiles <3″ width may have one fastener, profiles >3″ width must have two fasteners.

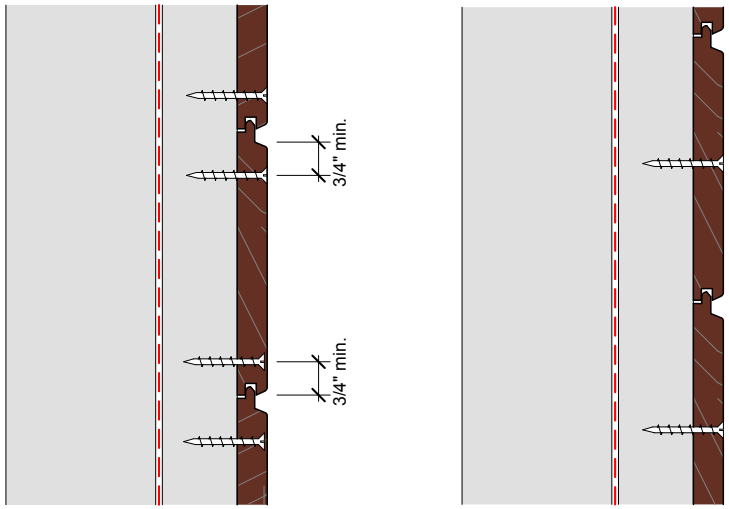
Installing Horizontal Siding

If face fixing, position fasteners minimum 3/4" above the overlap (do not fasten through the overlap), drive fasteners so they are flush with the timber surface.

For hidden fix T&G profiles, position the fastener minimum 1/2" from the tongue edge drive fasteners so they are flush with the timber surface.

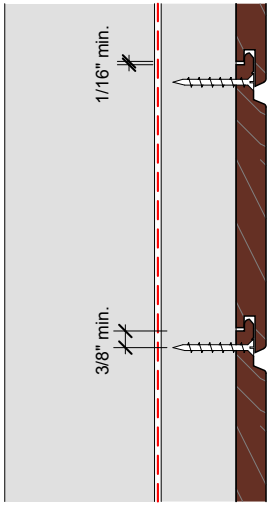
Ensure minimum 1/16" expansion gap to back of T&G boards.

○ Horizontal T&G Siding – Face Fixed

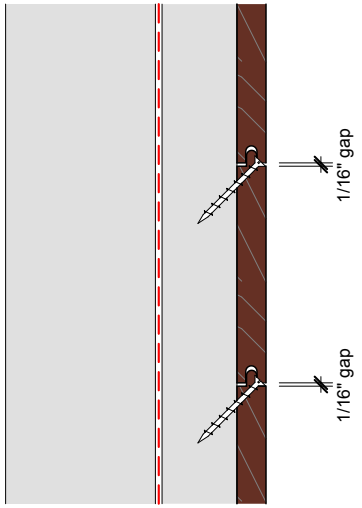


○ Profiles <5-1/2" width may be fixed with a single screw.

○ Horizontal T&G Siding – Hidden Fixed

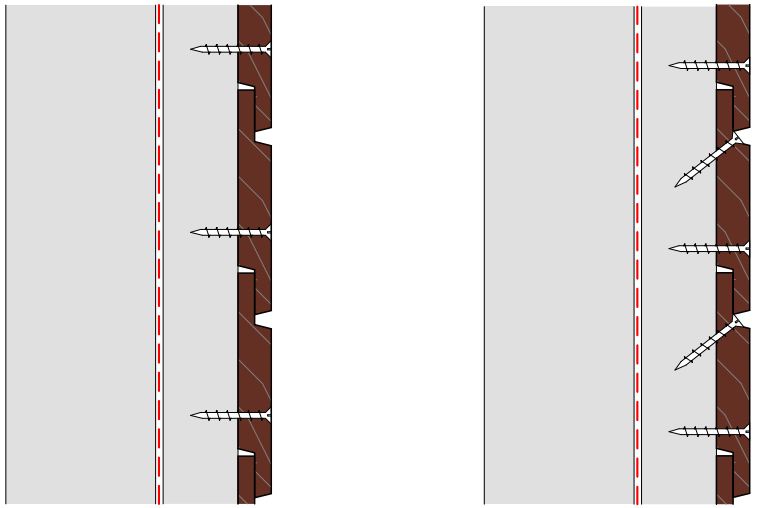


○ Horizontal T&G 'Nickel Gap' Siding – Hidden Fixed



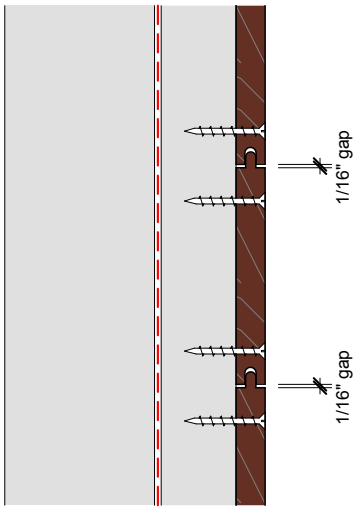
○ Profiles <5-1/2" width only.

○ Shiplap Siding – Face Fixed



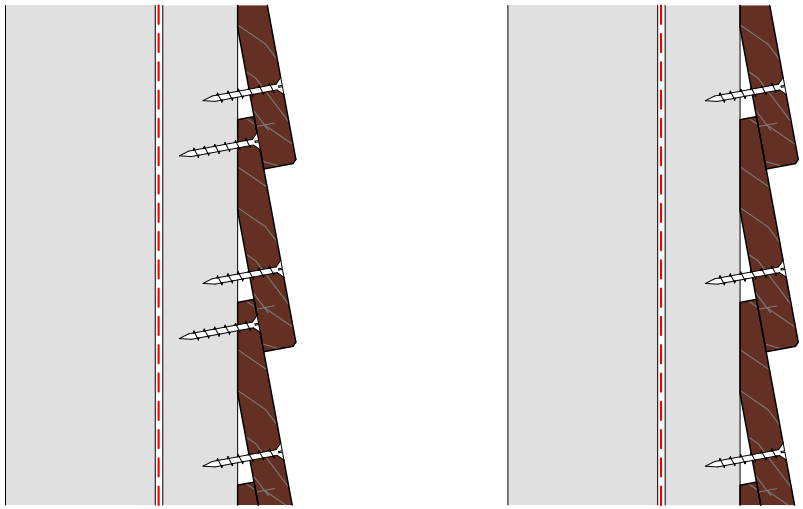
○ Profiles <5-1/2" width may be fixed with a single screw.

○ Horizontal T&G 'Nickel Gap' Siding – Face Fixed



○ Profiles <5-1/2" width may be fixed with a single screw.

○ Bevelled Siding – Face Fixed



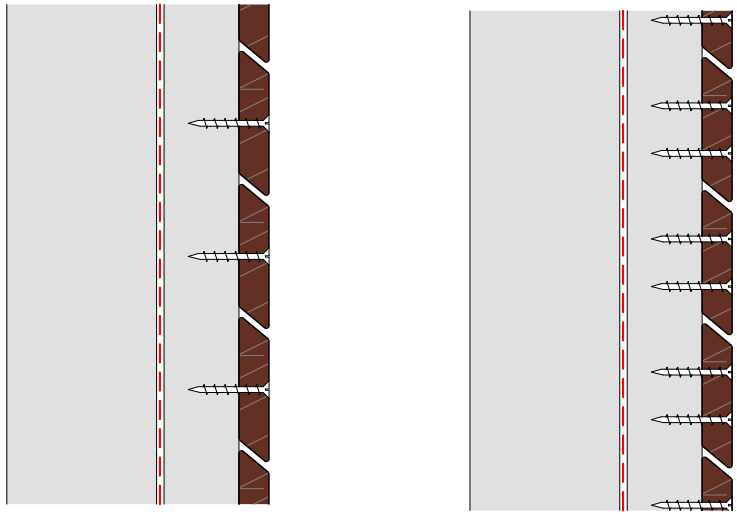
○ Profiles <5-1/2" width may be fixed with a single screw.

Horizontal Rainscreen

Position fasteners 3/4" from all board edges and drive them so they sit flush with the wood surface, do not overdrive.

Ensure minimum 3/8" expansion gap to edge of boards.

○ Face Fixed Open Joint Rainscreen



○ Profiles <3" width may have one fixing, profiles >3" width must have two fasteners.

Top of Wall

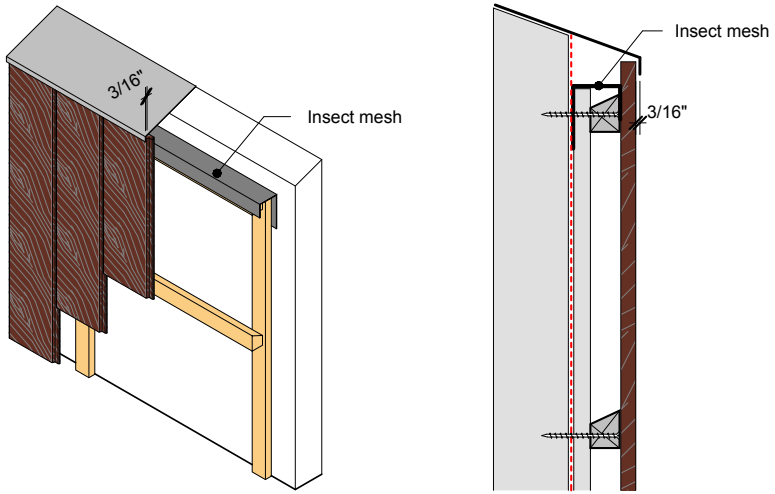
Allow minimum 3/16" gap at top of the wall to soffit to allow airflow.

For vertical siding or rain screen, apply a 15° reverse angle cut to all exposed board ends to create a drip edge.

Seal all exposed end grains with a high solids timber end grain sealer to prevent sapping of moisture. Cover end grains with a flashing where possible.

Apply mesh or fluted ventilation batten to prevent pests and rodents travelling into the cavity.

○ Top of Wall



Base of Wall

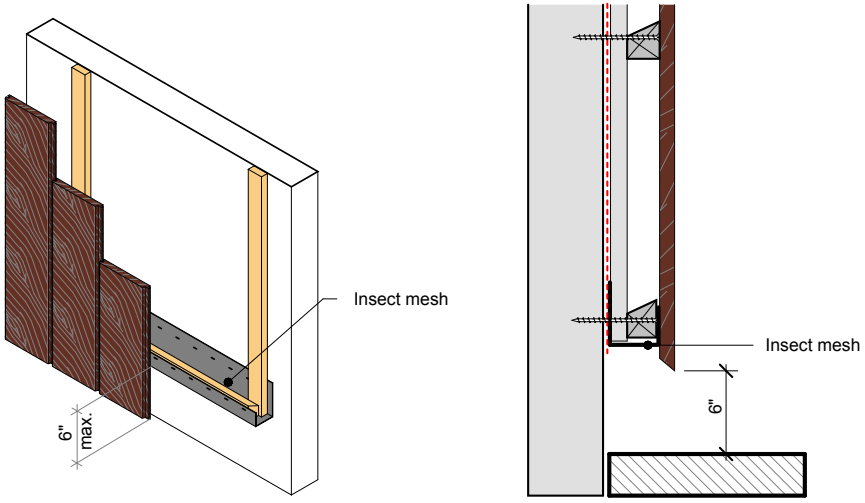
Allow minimum of 6" gap from base of siding to well drained ground. A larger gap may be considered in wet climates.

For closed joint siding apply mesh, perforated flashing or fluted ventilation batten to base of cavity to allow airflow while preventing pests travelling into the cavity.

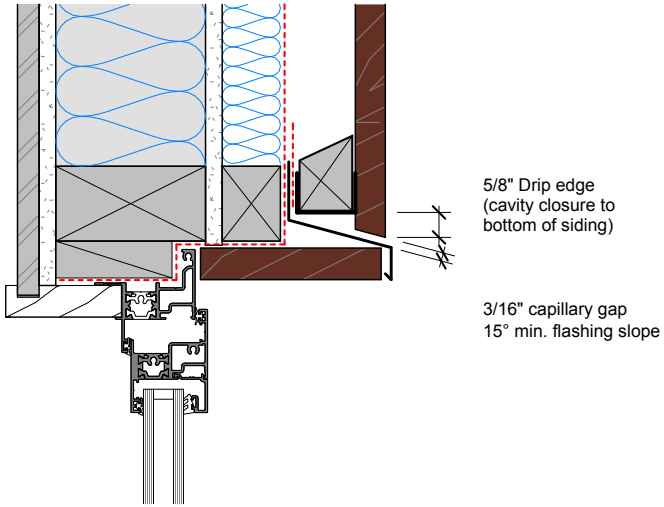
For vertical siding, apply a 15° reverse angle cut to board ends to create a drip edge.

Seal exposed end grains with a timber high solids end grain sealer to prevent sapping of moisture.

○ Base of Wall



○ Allow a Gap to Flashings



Allow minimum 3/16" gap to flashings or adjacent materials, ensuring minimum 15° fall of flashings, so that water deflects away from the building.

Vertical siding may have maximum 6" overhang from last fastened batten point.

Joints

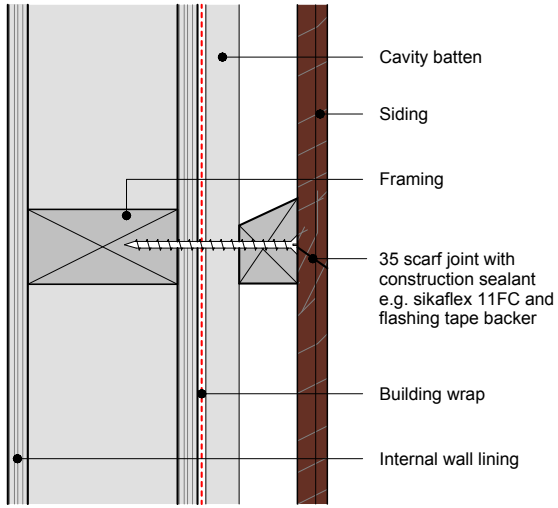
Joints between siding board ends must be made over cavity battens only.

At each joint, install one fastener per board end, placed at least 1/2" from the board edge. Pre-drill to prevent splitting.

A closed joint may be created using a 35° miter at board ends, and application of sealant at the joint e.g. Sikaflex 11FC. This type of joint is best suited to T&G profiles as the profile locks the joint together. Alternatively an open joint may be created with a minimum 3/16" gap to board ends. Vertical orientation apply a 15° angle to board ends to shed water away from the joint. Off-set joins by mimimum 16" OC.

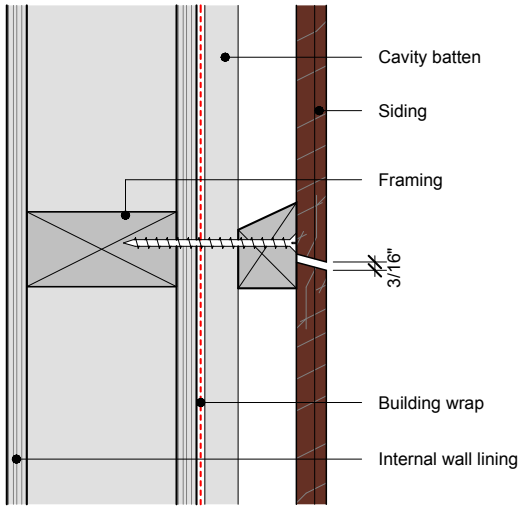
Seal exposed ends with an appropriate end grain sealer.

○ Miter Joint



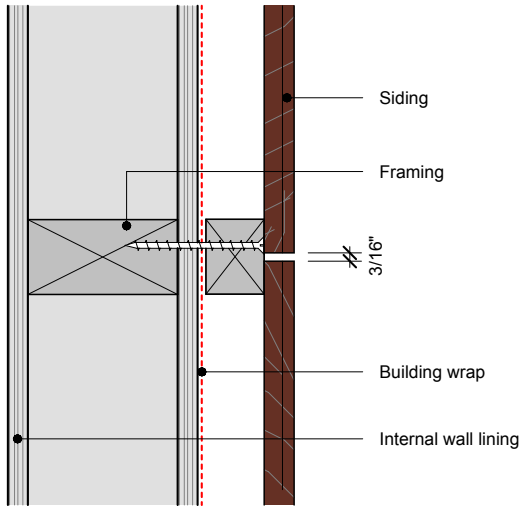
○ Closed Siding – Miter Joint.

○ Vertical Butt Joint with 3/16" Gap



○ Vertical Open Joint Siding – Butt Joint.

○ Horizontal Butt Joint with 3/16" Gap



○ Horizontal Open Joint Siding – Butt Joint.

Corners

Correct detailing of corners is important to maintain the integrity of the siding system. There are numerous options for corners, see following for a few examples.

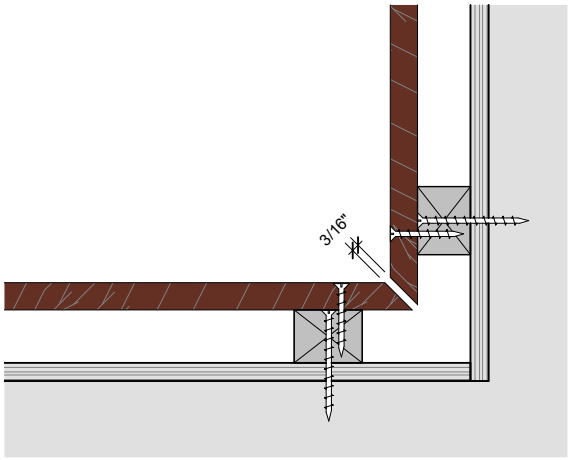
Please check with your local Abodo distributor for other options.

Fasten moldings with stainless steel ring shank nails or screws at maximum 18" centers, ensuring minimum 3/4" fixing penetration into batten or siding.

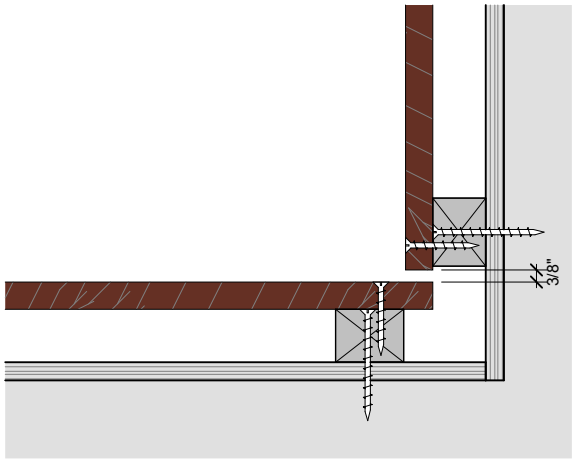
Some local building codes may require back-flashings to corners, please check prior to construction.

Closed in miter joints are not recommended as they can open and become a weak point in the siding. If a mitered look is desired, an open joint or additional aluminium Y flashing may be used at the corner.

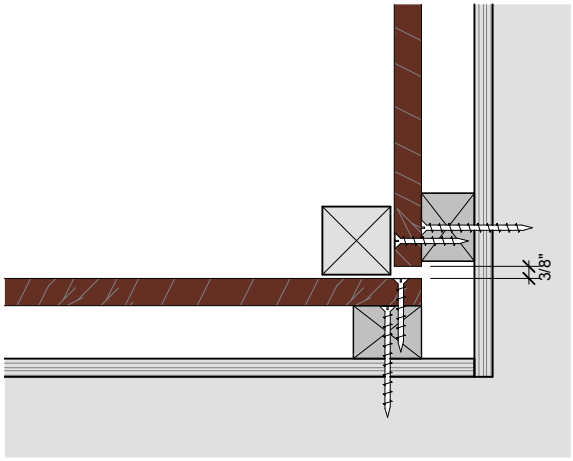
Internal Corners – Horizontal Siding



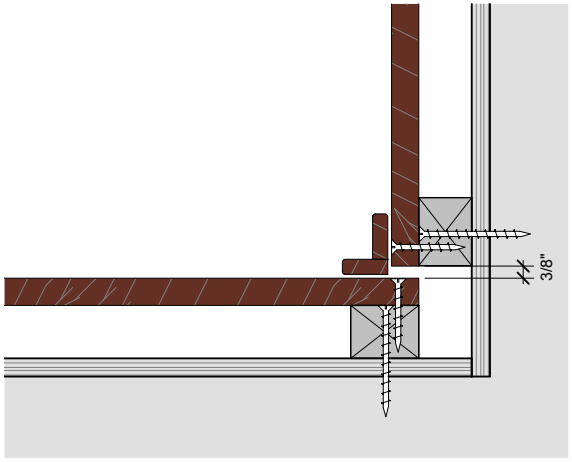
Open Miter.



Open Square Edge.

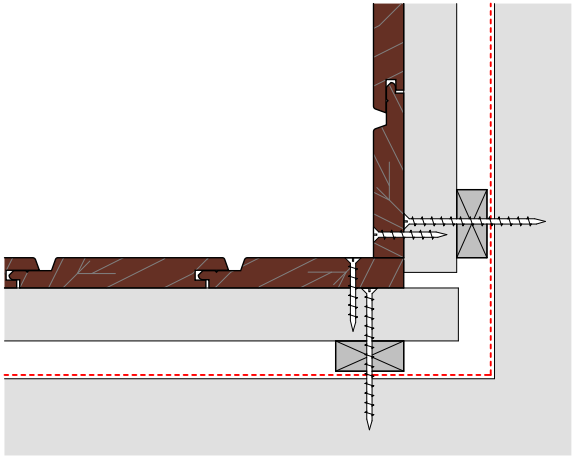


Internal Block Corner.

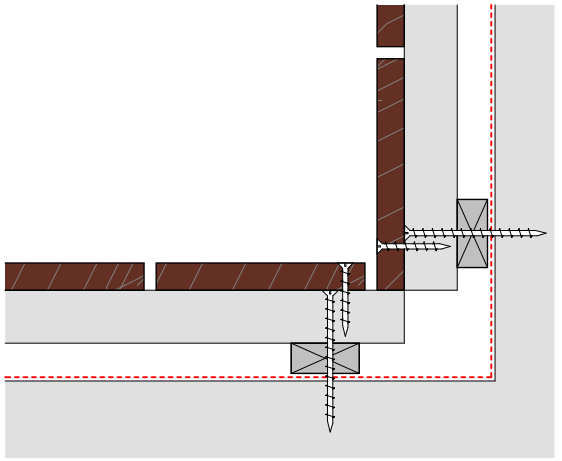


Internal Board Corner.

Internal Corners – Vertical Siding

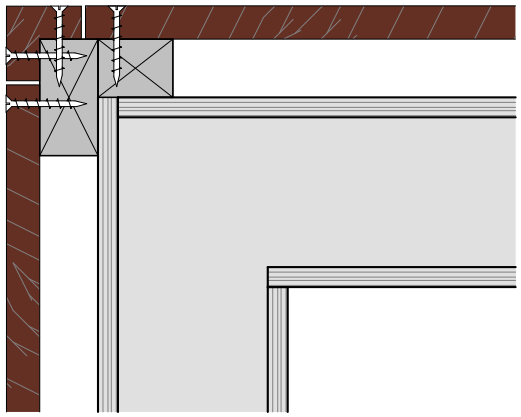


Closed Joint Siding Square Edge.

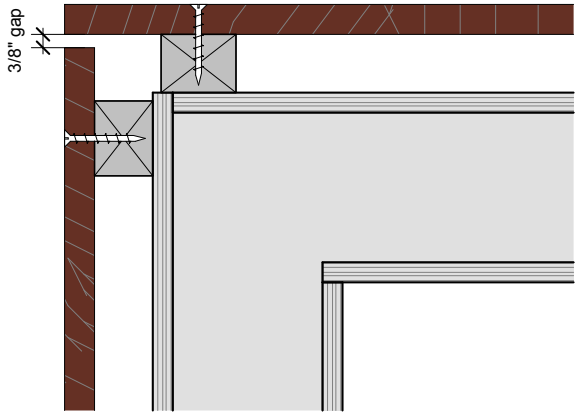


Open Joint Siding.

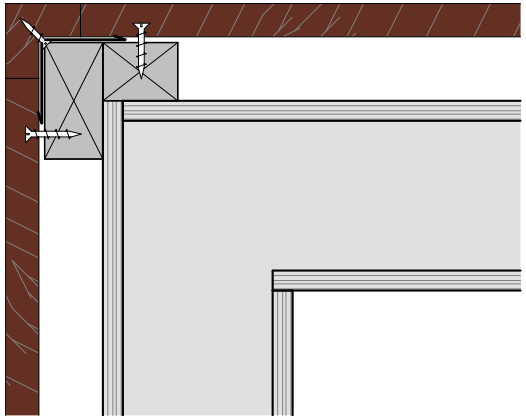
External Corners



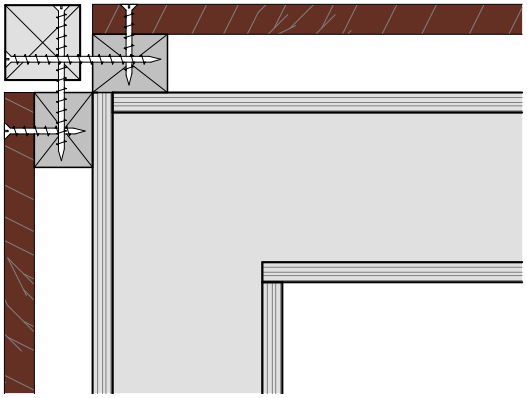
Corner Molding.



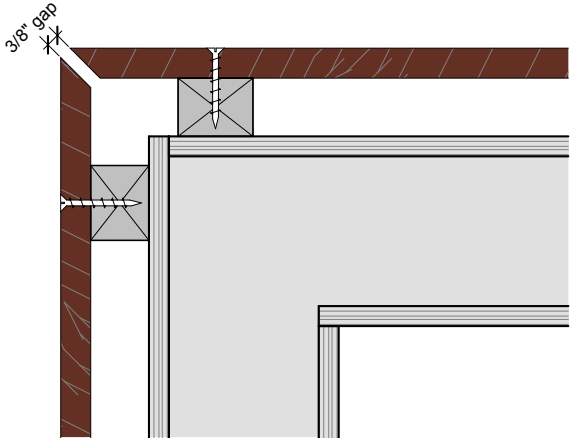
Open Butt Joint.



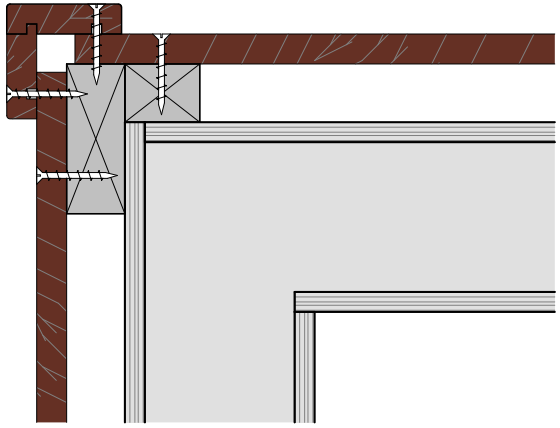
Corner Molding Flashing Back-fastened.



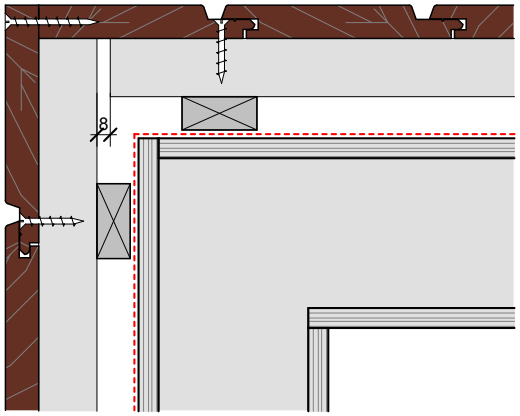
Block Corner.



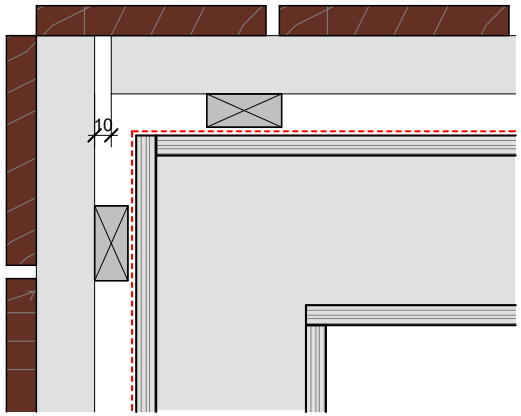
Open Miter.



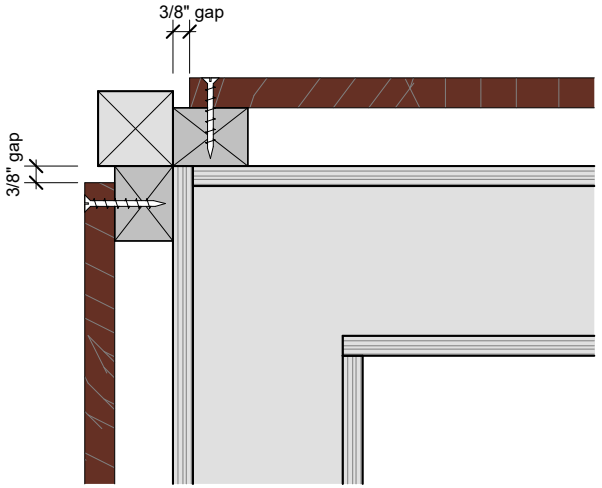
Box Corner.



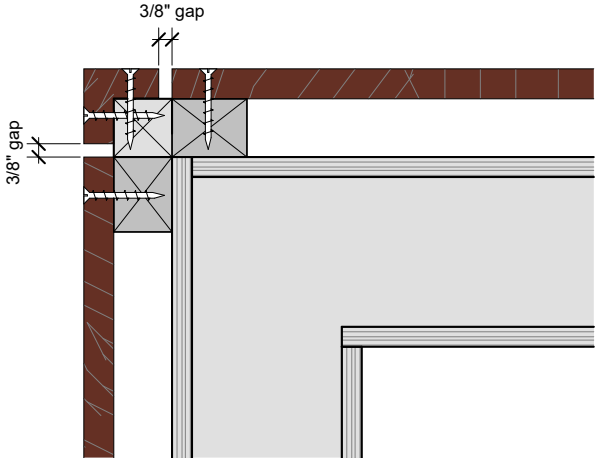
○ Vertical Butt Joint.



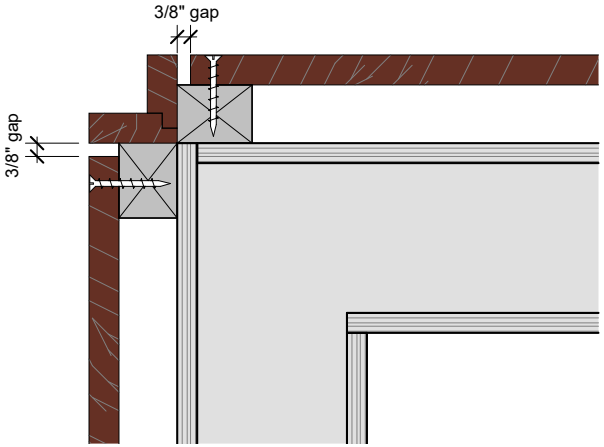
○ Vertical Open Butt Joint.



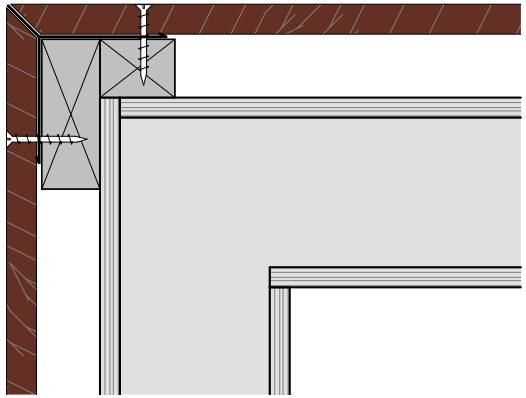
○ Exterior Block Corner.



○ Exterior Corner Molding Gaps.



○ Exterior 2-piece Corner.



○ Exterior Corner with Y Flashing.

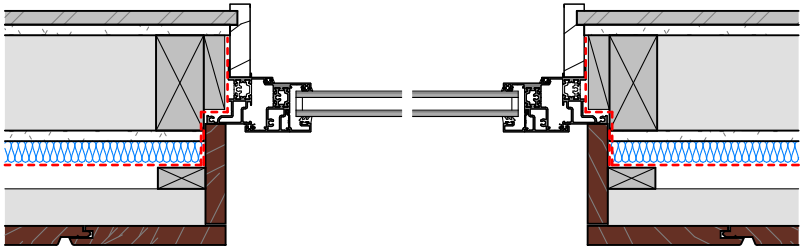
Windows and Doors

There are numerous ways of creating window and door openings within a timber clad facade, these are typically influenced by the design of the project.

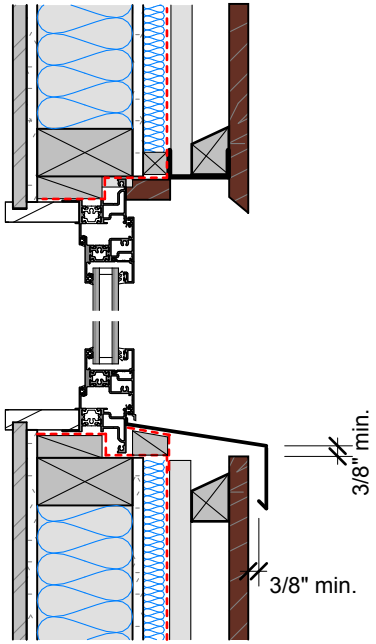
Certain principles remain the same:

- The joint between the window casement and surrounding wall is important and needs to be weather tight (and fire resistant if required).
- Wherever possible there should be rain and wind-proofing layers separated by a well-ventilated cavity.
- Install cavity barriers if required by the project specification to ensure fire resistance.
- Windows to be flashed appropriately to ensure that external moisture is directed away from the cavity to the outside of the wall. Properly designed and installed flashing is essential, especially at the windowsill including:
  - Consider vertical ‘waterbars’ at sides and rear.
  - Window head flashing shall be installed with a 5/8″ slope and drip edge and stop ends to channel water away from the cavity to the outside of the wall.
  - Leave adequate gaps where board edges/ends meet flashing/sills (min 3/16″ - 3/8″). Window head to have a 3/16″ minimum capillary gap between head/sill flashings and siding board.

○ Closed Joint Siding Window Opening

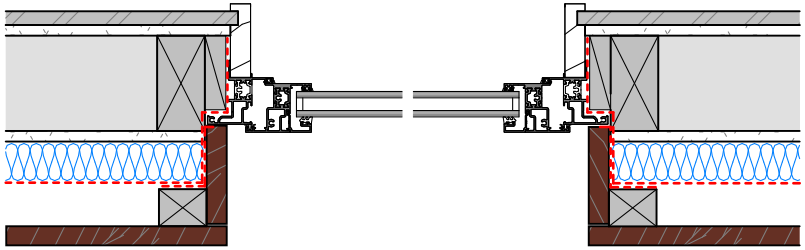


○ Plan View.

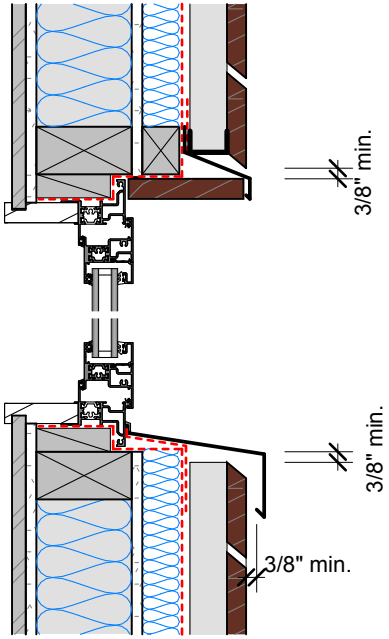


○ Section.

○ Open Joint Siding Window Opening



○ Plan View.



○ Section.

○ All drawings are for illustrative purpose only and are not to scale.

○ These siding arrangement drawings are generic scenarios. If more complex arrangements are required, e.g. for multi storey buildings, it is advised to consult an architect or structural engineer to assure safety through design.

Finishes and Coatings

Due to it's high durability, low resin content and inherent dimensional stability, Vulcan is an excellent substrate for most coatings.

Uncoated or Clear Coated Timber

If left uncoated or clear coated, all wood will change to silver grey eventually. Vulcan Siding can be left uncoated to weather naturally – changing in appearance with exposure to the elements. Some surface checking (cracking), mold growth and additional dimensional movement can be expected as part of the weathering process.

Application of a pigmented coating will enhance the aesthetic performance of the wood over time and help maintain color.

When deciding whether to use a surface coating or finish there are factors you should consider:

- The aspect of the siding: south or west facing (northern hemisphere) are more exposed to both sunlight and driving rain so will weather more quickly. Northerly or eastern facing walls will be shaded and appear darker and may require more frequent cleaning.
- Shade from a canopy, overhanging trees or nearby buildings may also have a localized impact and cause variations in color on the same elevation.

To counteract these factors or simply to add another dimension to your siding, various types of coatings and finishes are available. Selection of the correct coating is very important as incorrect coating selection can lead to future problems associated with coating failure and excessive maintenance.

Color Selection

Where a natural brown color is desired, a translucent brown pigmented coating should be used. By using darker wood finishes, maintenance requirements by way of re-coat period will generally increase. Highly exposed orientations should be designed for easy access for re-coat. Lighter colors and shades of grey allow the timber to age gracefully in highly exposed applications, so are preferable here.

On exposed high elevations, choose wood coatings that are more durable, such as exterior-grade paint, reactive wood stains, or slivering erosion finishes that are designed to wear naturally over time.

In high sun exposure situations darker colors such as black can cause the timber to heat up quickly causing 'shock', this can lead to increased movement, surface cracking, and possible early failure of coatings.

There are translucent stains offering partial color effects and solid pigmented coatings which give a completely opaque look. Clear oils offer limited UV protection so the timber will 'silver off' over time.

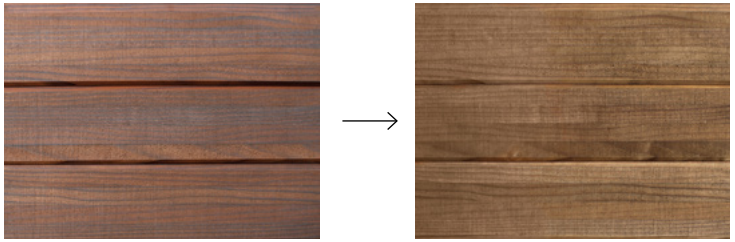
Many coatings have water repellent, moldicide/fungicide and/or UV protection built-in and this is recommended for any semi-transparent coating.

Factory vs Site Finishing

Where possible, factory finishing is recommended as this ensures siding is coated all sides with the correct amount of coating consistently applied with associated quality assurance.

In all cases coating should not be commenced unless timber is in a dry state with moisture content less than 14%.

Always ensure coatings are tested on Vulcan timber prior to use and refer to product supplier and coating manufacturer for guidance.



Vulcan Teak
As delivered

Vulcan Teak
Weathered 12 months
exterior install

Vulcan Clear
As delivered

Vulcan Clear
Weathered 12 months
exterior install

○ These images show how the timber color lightens over time.

Film Forming Semi-transparent Coatings

Transparent film forming coatings including polyurethanes and some semi-transparent acrylics create a film on the surface of the wood. As they are semi-transparent, UV can penetrate onto the timber surface leading to possible failure of the coating. Significant discoloration can occur when moisture enters flaking parts of the coating, this can cause mold growth and decay under the coating itself.

Once flaking or cracks start it may be necessary to strip the coating back to bare timber before re-coating, creating substantial work.

These coatings are not suitable for highly exposed applications unless very regularly maintained. They may be suitable for protected and semi protected applications such as millwork or exterior trim.

For these reasons semi-transparent or translucent film forming coatings should be avoided in exposed siding applications.

Penetrating Oils and Erosion Stains

Penetrating oils and stains are designed to penetrate the timber surface while enhancing the visual natural aesthetic of the timber. They are designed to erode with exposure to the weather, hence avoiding cracking or flaking associated with film forming coatings. They are also microporous allowing moisture to easily escape from the timber substrate if it gets wet.

These coatings will tend to erode over time with exposure to UV and rain and need to be re-coated when they start becoming patchy; typically between 2-4 years depending on exposure to the weather.

The re-coating process is relatively easy compared with film forming coatings and paints, as it only requires a wash down prior to maintenance coat.

Abodo recommends penetrating erosion coatings for a semi-transparent siding finish – Abodo Protector is an example of this coating.

Paints

Paints have the longest re-coat cycle, this is almost exclusively based on pigment and film build. As they are opaque in color, paints do not allow any show-through of natural timber grain. Like film forming transparent coatings, it is critical that paints have a re-coat towards the end of their service life, typically around 8-10 years depending on exposure.

While the re-coat period is longer than penetrating oils and stains, the re-coating process is more labor intensive due to the need for preparation including stripping and sanding.

Heat attracted from darker colors can cause excessive movement, cracking and flaking. When painting siding with dark colors it is recommended to apply at least one topcoat to the exposed face and lap line prior to installation, this will reduce the chance of visible primer lines should the timber shrink in service.

Exterior grade acrylic paints are recommended with flexibility in the coating surface that allows for expansion and contraction of the timber substrate. Application of a primer with tannin blocking properties is recommended prior to application of paint topcoats. Please refer to paint manufacturer's specific recommendations.

It is recommended to factory pre-finish painted siding where possible. If primed siding is shipped to site, then an oil borne primer should be used to seal the wood from moisture ingress prior to top coating.

Paints must be well maintained with sufficient film build. Should the film be allowed to crack or flake, moisture can be trapped inside the wood and cause premature failure and decay.

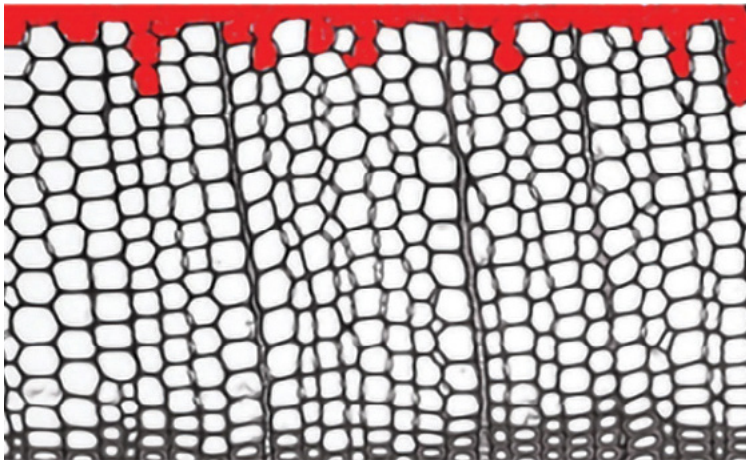
Surface Finish – Impacts on Coatings and Weathering

Many semi-transparent oils and stains are designed to penetrate into the wood surface. How the cell structure is formed and its condition (i.e. broken open or closed off) makes a big difference to how much a stain can penetrate and its corresponding long term performance.

In addition, stains can only penetrate while they are in a 'liquid' form. Fast drying modern waterborne stains do not allow much time for penetration before the coating dries and changes from a liquid to a solid. In some instances, waterborne penetrating oils (e.g. Abodo Protector) can penetrate into the cells better than a regular waterborne stain.

Earlywood bands are more open and easier to penetrate, however latewood bands (autumn/winter) are smaller and denser so don't allow coatings to penetrate as well. Even during processing to achieve a bandsawn finish, the latewood areas do not 'lift up' like the earlywood areas, leaving bands of dense and difficult to penetrate cells.

Surface finish can have a significant effect in the penetration of coatings, along with the amount of coating used and corresponding performance.



○ Penetration of coating into wood cells.

Smooth Dressed Face

Smooth dressed timber produced in modern high-speed planers can have a glass-like finish and resists coating penetration. This can reduce durability of coatings. Smooth dressed surfaces must be thoroughly sanded with 120-150 grit sandpaper prior to application of coating to ensure absorption.

When applying semi-transparent penetrating coatings, a bandsawn, distressed or brushed face is recommended (see adjacent).

Paint finish may be applied to smooth dressed or textured timber.

○ Abodo Vulcan smooth finish – uncoated.

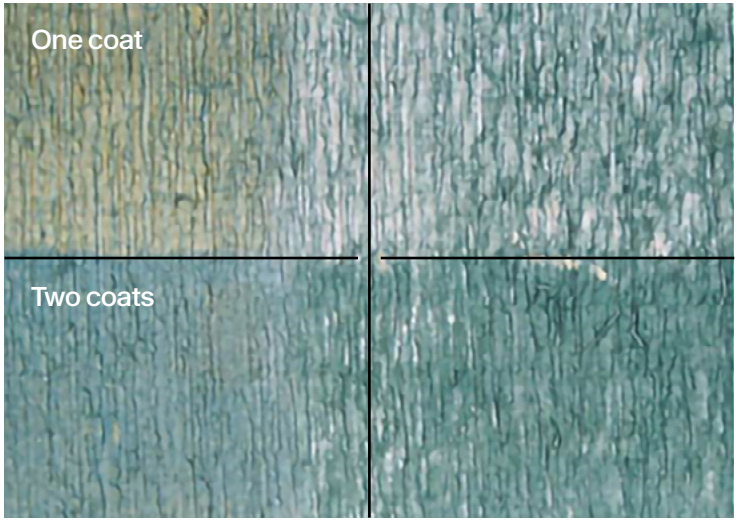
○ Smooth dressed timber stain finish – one coat (top), two coats (bottom), covered (left), exposed to the weather (right).

Bandsawn Face

Bandsawn faces perform significantly better than smooth faces in terms of coating performance.

A bandsawn surface allows the coating to penetrate deeper into the cells of the wood due to increased surface area.

Abodo Vulcan bandsawn finish – coated in Iron Vitriol.



Bandsawn timber stain finish – one coat (top), two coats (bottom), covered (left), exposed to the weather (right).

Brushed Face

When exposed to weather, timber will eventually erode back over time, the softer earlywood rings will erode first, while the harder latewood will remain. In most softwood species this means a ribbed surface will develop on the surface of the wood over time.

Brushing the surface of the wood with a spinning nylon brush can pre-empt nature by scouring the softer early wood away in advance, allowing the wood to be sound substrate for coatings though not as effective as bandsawn.

Abodo Vulcan brushed finish – coated in Protector – Teak.

Distressed timber finish.

Distressed Face

Modern machining techniques mean some equipment can apply a rough or distressed finish direct from the planer. A distressed finish incorporates a combination of micro reeded and rough machining to create a textured surface that accepts and holds coatings similarly to a bandsawn finish.

Grain Orientation

Grain orientation has a significant effect on long term weathering. Flat grained timbers are more likely to show more surface cracking over time, while vertical grain pieces are less likely to crack. Coatings will last longer on timbers with vertical grain orientation.

Abodo offers Vulcan Vertical Grain Siding that will provide better weathering performance than flatsawn timber.

○ Effects of heavy weathering (shown here on chemically treated Radiata Pine). Bottom piece was cut with a vertical grain/quartersawn orientation, top piece is plain sawn and exhibits severe surface checking.

○ Summary/Vulcan Siding Coating Recommendations

- Factory applied coatings with an extended maintenance system are best for consistent quality and long term performance. Many timber siding suppliers offer this service.
- Exterior coatings must have biocide included to protect against mold growth.
- Surface texture is important. Coatings generally perform better applied to sawn or distressed rather than smooth planed timber.
- Smooth dressed timber must be thoroughly sanded prior to coating.
- When using translucent coatings, moisture-permeable erosion coatings such as Abodo Protector or equivalent are recommended. Specially developed for external timber, they are resistant to cracking, flaking and peeling associated with more brittle varnishes or paints which can trap water under their surface.
- Paints may be applied, ideally with a tannin blocking primer.
- Paler colors, especially white, reflect heat. Darker colors may be used but will put additional stress on the timber due to heat.
- Before using a coating ensure that it has been adequately tested on the timber including adhesion and exposure testing (please consult coating manufacturer for further information).
- Timber must be less than 14% moisture content before commencement of coating.
- If possible, seal all sides of timber siding with at least one coat prior to installation.
- Thoroughly seal timber end grain with a high solids end grain sealer to prevent water migrating into ends.

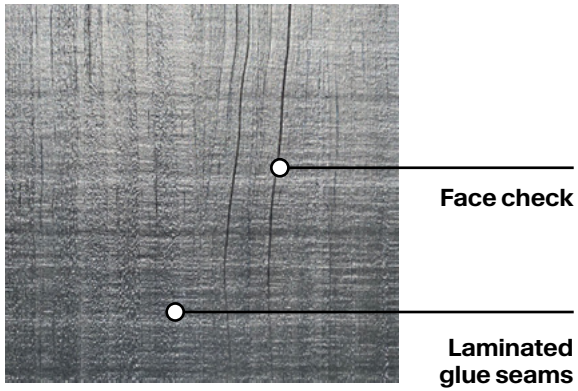
Maintenance

The natural weathering process of exterior timber, from exposure to moisture and UV, causes rapid lightening or silvering of timber. If left uncoated, the same will occur with lighter colored semi-transparent coatings such as whites and greys.

Accumulation of environmental contamination such as dirt and pollen can influence the weathering process.

Mold growth can occur as natural sugars migrate to the surface, which results in a change in color over time. Darker molds tend to set into and stain timber for longer than green molds or algae and thus should be acted on promptly. Green colored surface algae are typically easier to remove. Mold is distinct from wood destroying fungus in that it does not cause wood decay but can result in poor aesthetics and affect coating performance.

Checking (cracks) may be observed on the face and ends of Vulcan timber. Checks are acceptable to install. Checking may become more apparent as the material weathers naturally in place. Fiber pull at laminated glue lines is also possible. These are not defects and are considered a natural part of this wood product. Maintenance with a coating and thorough sealing of end grains with wax sealer will improve long term weathering characteristics.



Cleaning

Annual washing is recommended as minimum maintenance for any exterior timbers.

The use of a low pressure wash, with a neutral pH detergent based cleaner and soft brush is recommended. A soft-bristled brush loosens up grime and mold growth that may build up on the surface of timber. Rinse thoroughly with low pressure water.

Do not water blast timber, as high pressure can damage the fibers of the wood, and cause permanent damage to the surface, and the coating.

Where heavy discoloration occurs, a stiff bristle brush may be used, although this may strip some or all of the existing coating from the wood.

For areas with heavy mold or discoloration and prior to coating, a specialist timber cleaner should be used. Timber cleaners may include oxalic-acid and percarbonate oxygenating products. Bleach based cleaning products (Sodium hypochlorite) must be used with caution as higher concentrations can damage the timber surface.

Spray-on slow-acting moldicides may also be used after cleaning and/or coating to help prevent future mold growth. These products will typically contain a biocide such as benzalkonium chloride (BAC) and will require re-application after 6-12 months.

Annual Maintenance Check

During an annual wash, siding and junctions should be inspected for weathertightness, coating erosion and general weathering. Clear all gutters and trim back foliage from trees or plants touching the siding as this can result in abrasion of the timber surface and coating.

Repairs must be made to ensure the weather tightness and integrity of the siding system.

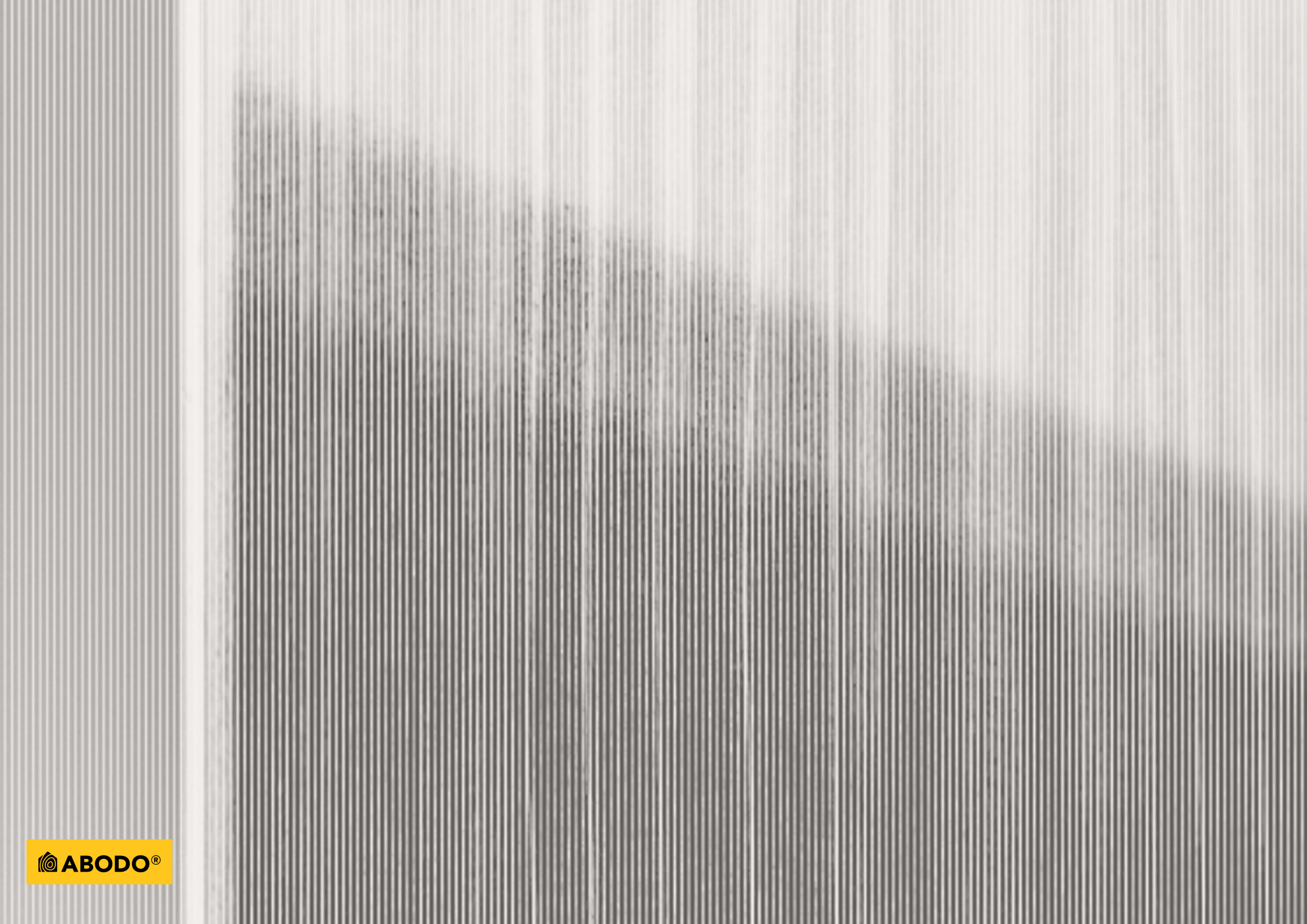
Re-coating

Should the timber appear to require re-coating, this must be done after thoroughly washing down with a specialist timber cleaner and then allowing to dry. Paint finish may require further preparation by sanding or stripping back of coating. Always refer to coating manufacturer's instructions first.

As a general rule an erosion stain is expected to have a re-coat every 2-4 years and paint finish 8-10 years though this is dependent on coating, surface finish used and local environmental conditions including level of exposure to the weather.

○ Acknowledgments:

Abodo wish to thank the UK Timber Development Association and Resene Paints for providing information and access to content for parts of this guide.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