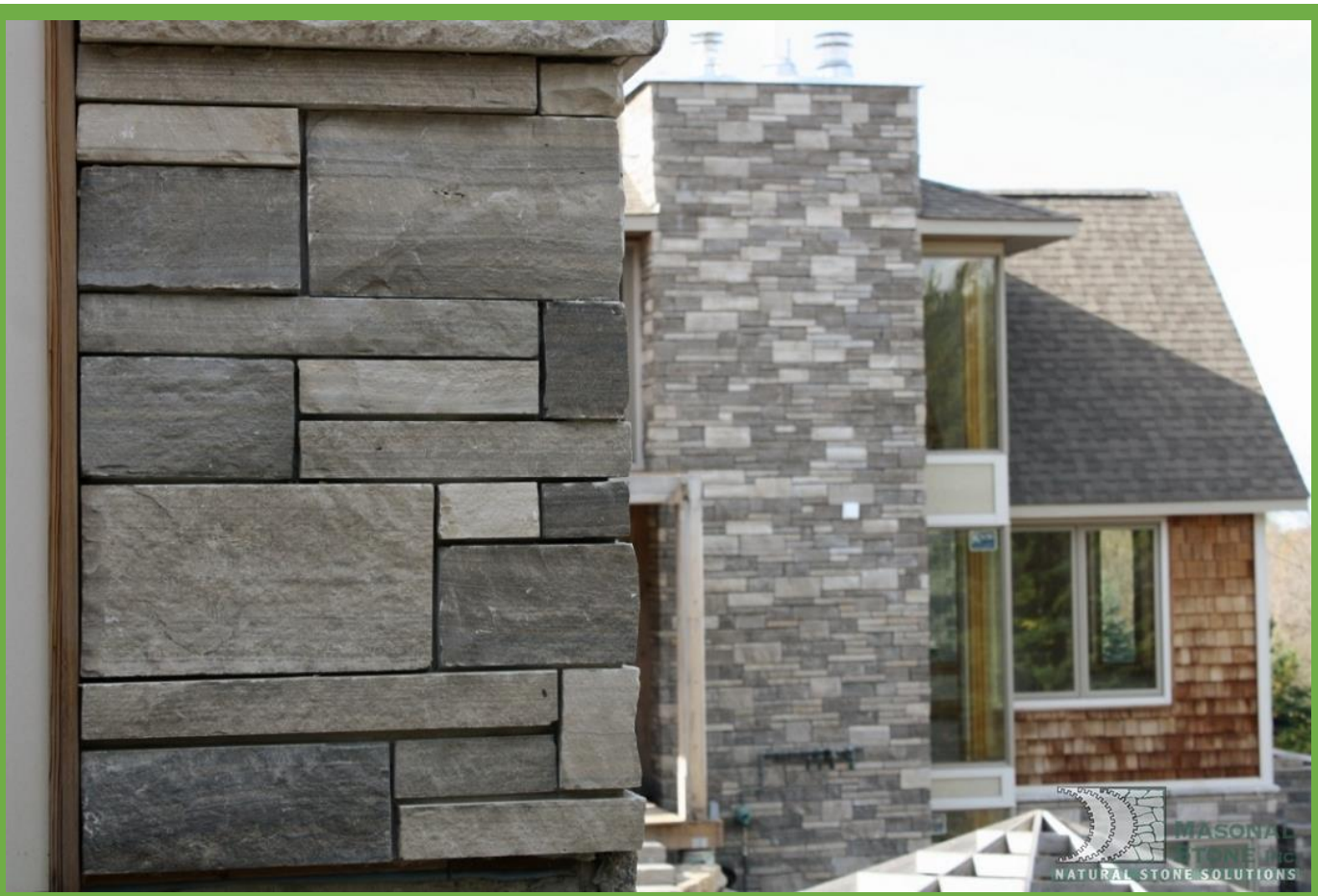
MASONAL STONE INC.
NATURAL STONE SOLUTIONS

PICCO ENGINEERING

THIN STONE VENEER: TECHNICAL INSTALLATION GUIDE



Produced by PICCO Engineering

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Disclaimer

This document is intended to serve as a guideline for the installation of thin adhered stone veneer. The use of this guideline with respect to other veneer types and installation methods is not recommended. PICCO Engineering takes no responsibility for any installation or installer which references this manual for any other type of veneer system.

Information contained in this document was obtained from ASTM, Masonry Structures Joint Committee, Marble Institute of America, International Building Code, and NBCC codes and standards. The information contained herein is, to the best of PICCO Engineering's knowledge, accurate and relevant. Due to the nature of the codes and standards, information in this manual is subject to change. PICCO Engineering assumes no responsibility for errors or omissions contained in the information provided by such codes and standards. Review and follow local building codes and standards as they take precedence over this document. This document should only be used as a guideline alongside applicable building codes and standards.

This document is to be used as a guideline for competent and experienced installers of adhered veneer. PICCO Engineering takes no responsibility for the integrity and stability of any installation of adhered stone. Installers and designers of adhered veneer following and referencing this guideline assume all liability for the design and installation of the adhered veneer system.

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The drawings and details in this manual are intended to be used as illustrations only, and are not to be used as to scale representations of details to be used in technical drawings or designs. PICCO Engineering takes no responsibility for any person using details referenced in this manual as scale drawings.

PICCO Engineering is not liable for any injury or damages caused by the installation of adhered veneer systems at any point the life span of the adhered veneer system.

Introduction

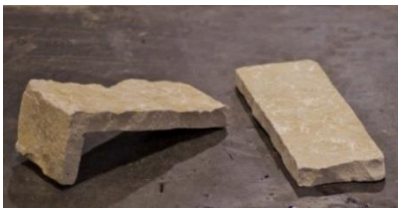
What is Thin Stone Veneer?

Thin stone veneer is a natural or manufactured product with a nominal thickness of 1-1/4" (typically) and weighs no more than 15 lbs. /sq. ft. This weight is limited by multiple building code and standards. Examples of standards that define thin stone veneer are as follows:

1. ***MSJC Building Code Requirements and Specifications for Masonry Structures Section 6.3.2.1 (based on TMS 402-08/ACI 530-08/ASCE 5-08)*** *- "Adhered veneer units shall not exceed 2-5/8 in. (67 mm) in specified thickness, 36 in. (914 mm) in any face dimension, nor more than 5 ft^2 (0.46 m^2) in total face area, and shall not weigh more than 15 lbs. /ft^2 (73 kg/m^2).*
2. ***MIA 2016 Section 1.3.2*** *– "Units shall not exceed 36 in. (914 mm) in the greatest dimension nor more than 720 in^2 (0.46 m^2) in total area and shall not weigh more than 15 lbs. /ft^2 (73 kg/m^2) unless approved by local governing officials and the engineer of record."*

Unlike full thickness veneer, thin veneer stone does not need to be mechanically anchored to the backup structure. Instead, adhesion alone is considered to be solely sufficient to transfer the loads. Typical adhesion materials for thin stone veneer are mortar and epoxy adhesive (only permissible for interior applications).

Thin stone veneer is usually pre-fabricated and cut before it reaches the construction site. Pre-sized flat stone and 90 degree corner pieces allow for the installer to erect the wall with minimum need for stone cutting and trimming.



Required Materials and Recommended Tools for Thin Stone Veneer Installation

REQUIRED MATERIALS:

- **Water Resistive Barrier (WRB):** The National Building Code of Canada (NBCC) refers to WRB's as "Sheathing Membranes – Breather Type" (SM-BT). The NBCC states in Clause 9.27.3.2. – "Sheathing membranes shall conform to the performance requirements of CAN/CGSB-51.32-M" (CGSB – Canadian General Standards Board). Refer to local building codes to determine if a rain screen is also required. For more information on rain screens see NBCC Clauses 9.27.2.4 through 9.27.3.4.
- **Mortar:** Type N or S mortar shall be in conformance with CAN/CSA-A179 for Mortar and Grout for Unit Masonry or ASTM C270. If Portland-Lime Cement is used, it must conform to ASTM C207 and C150. If Masonry Cement is used, it must conform to ASTM C91. If Mortar bonding agents are used, they must conform to ASTM C1384.
- **Epoxy Adhesive:** Used for interior applications only. Refer to Manufacturer's instructions.
- **Flashing:** Apply corrosion-resistant flashing where applicable. Refer to local building codes for applicable flashing types and locations.
- **Weep Screeds:** Refer to local building code if a corrosion-resistant weep screed is required on an exterior installation. Weep screed should be installed as per the Building Code and Manufacturer's requirements and instructions.
- **Corrosion Resistant Metal Lath:** Minimum 2.5 lbs. /sq. yd. Diamond or Rib Mesh Metal Lath that must conform to ASTM C847.
- **Fasteners for Metal Lath:** Galvanized nails, staples or screws that must conform to ASTM C1063.

Recommended Tool and Equipment List				
General Safety:	***Metal Lath Installation:***	***Mortar Preparation:***	***Stone Veneer Installation:***	***Grouting & Finishing:***
Safety Glasses	Suitable Bits for Fasteners	Wheelbarrow	Diamond Blade Hand Grinder	Grout Bag or Grouting Gun
Work Gloves	Power Drill or Staple Gun	Shovel or Hoe	Hammer and Chisel	Masonry Jointer
Dust Mask	Galvanized Screws or Nails	Mixing Sand	Level	Masonry Brush
Certified Steel Toe Boots	Stud Finding Tool	Masonry Trowel	Tape Measure	Stone Cleaning Agent

Installation Guideline

Step 1: Preparation of Backup Substrate for Thin Stone Veneer Application

The typical backup substrates in which thin stone veneer can be applied to are separated into two major categories, Continuous and Non-Continuous.

OPTION 1 (Step 1.1): Non-Continuous Substrates:

- Wood Stud Framing
- Metal Stud Framing

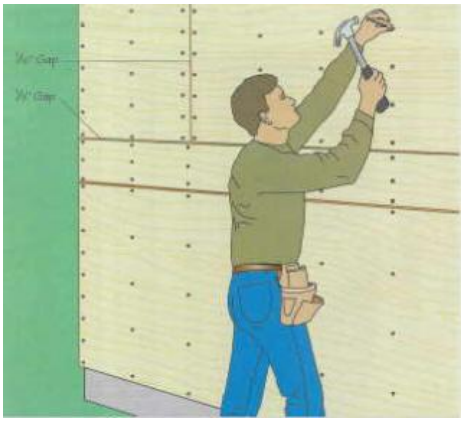
OPTION 2 (Step 1.2): Continuous Substrates:

- Cast-In-Place Concrete
- Concrete Masonry Units (CMU)
- Brick Masonry
- Cementitious Stucco
- Insulated Concrete Forms (ICF)

Note: Step 1.1 and 1.2 are two independent options with respect to each other. Follow the relevant step based on the type of substrate used on the specific project.

Option 1 (Step 1.1): Non-Continuous Substrates:

Step 1.1.1 - Apply Wall Sheathing (Exterior & Interior):



Example of installation of wall sheathing.

For any typical exterior or interior stud framing wall, a layer of sheathing will need to be fastened directly to the studs in order to provide a solid uniform surface for the following layers that need to be applied. The thickness of the sheathing will vary based on the required project specifications. Materials such as Oriented Strand Board (OSB), Plywood, wallboard, cementitious board or exterior grade drywall are all common examples. Thickness and specifications of wall sheathing can be determined from NBCC Section 9.23.17. Types and spacing of fasteners for wall sheathing can be determined from NBCC Section 9.23.3.5. Tables for both can be referenced below. Note that these tables only apply for buildings that meet NBCC Division A Subsection 1.3.3.3.

Table 1: Wall Sheathing Thickness

Type of Sheathing	Minimum Thickness, mm		Material Standards
	With Supports 406 mm O.C.	With Supports 610 mm O.C.	
Fibreboard (insulating)	9.5	11.1	CAN/ULC-S706
Gypsum Sheathing	9.5	12.7	ASTM C1177 / C1177M ASTM C1396 / C1396M
Lumber Mineral Fibre, Rigid Board, Type 2 OSB, O-2 Grade OSB, O-1 Grade, and Waferboard, R-1 Grade Phenolic, faced	17.0 25 6.0 6.35 25	17.0 25 7.5 7.9 25	See Table 9.3.2.1. CAN/ULC-S702 CSA O437.0 CSA O437.0 CAN/CGSB-51.25-M
Plywood (exterior type)	6	7.5	CSA O121, CSA O151 CSA O153-M
Polystyrene, Types 1 and 2 Polystyrene, Types 3 and 4 Polyurethane and Polyisocycanurate Type 1, faced Polyurethane and Polyisocycanurate Types 2 and 3, faced	38 25 38 25	38 25 38 25	CAN/ULC-S701 CAN/ULC-S701 CAN/ULC-S704 CAN/ULC-S704

Step 1.1.2 - Apply Water Resistive Barrier (WRB) (Exterior Only):

For exterior walls only, it is recommended to apply a water resistive barrier (WRB) to prevent wind-driven rain and air moisture from penetrating into the interior components of the building. For example, an Asphalt Felt with building paper can be used as a sufficient WRB (however, local building codes may call for specific types). Prior to installing the WRB, install a weep screed (if the local building code requires it) not exceeding 4" (102 mm) above the concrete (or paved surfaces) or directly where the exterior framing meets the foundation.

To install a WRB, attach the strips in a shingle like pattern starting from the bottom of the wall. Overlap the horizontal joints by 2" (51 mm) and the vertical joints by 6" (152 mm). Install any flashing or support members before proceeding to Step 1.1.3. Please note that a WRB will not need to be installed for an interior application unless it is specified for the project or required by local building codes.

Refer to the local building code to determine exactly what is required for the water resistive barrier.

WRB being installed to structure.

Step 1.1.3 - Install Metal Lath (Exterior & Interior):

Overtop of the sheathing (interior application) or WRB (exterior application), Apply a corrosion-resistant metal lath, as per ASTM C847. A list of different types of metal laths can be found in Table 2.

The lath must be installed in an overlaying pattern. Overlap the horizontal joints by ½" (13 mm) and the vertical joints by 1" (25 mm). Please ensure that the lath is installed in the right direction (the lath should feel rough as you run your hand up it and smooth as you run your hand down it).

When approaching inside or outside corners, ensure that the vertical joints are overlapped a minimum 16" (406 mm) away from the corner. This will ensure no joint cracking over time.

For exterior applications, horizontal fastener spacing will vary depending on the substrate. For the various substrates and their corresponding fastener spacing, refer to Table 2. Fastener spacing is governed by ASTM C-1063. For wood stud, wood screws, nails, and galvanized staples can be utilized. For metal framing, self-drilling screws (SDS) can be used. Manufacturers of SDS include HILTI and ELCO.

To ensure proper load transfer between the lath and the backup structure, the minimum penetration of the staples, nails or screws into wood framing should be 1" (25 mm) and 3/8" (10 mm) for steel framing.

Metal lath being fastened to wall

OPTION 2 (Step 1.2): Continuous Substrates:

Step 1.2.1 - Remove Non-Cementitious Materials from Substrate (Exterior & Interior):

Continuous substrates such as concrete, CMU, masonry or stucco provide a sufficient mortar/epoxy adhesive bond for the thin stone veneer without the use of a metal lath.

In order to ensure the mortar/epoxy adhesive bond between the backup substrate and the thin stone veneer is sufficient, the surface must be removed of any non-cementitious materials such as paints, waterproofing, sealers, dust etc. This can be achieved through abrasive methods such as sandblasting or water blasting. Please ensure that all workers are wearing the proper safety equipment when conducting these procedures to avoid serious injury. This process will help to restore the wall to a clean and smooth condition, with the original substrate fully exposed.

Please note that cast-in-place concrete, CMU, and ICF walls provide sufficient water resistance. Therefore, a water resistive barrier is not required, unless it is specified for the project or required by local building codes and/or the design engineer.

Sandblasting CMU wall to remove non-cementitious material.

Step 1.2.2 - Install Wire Lath (Exterior & Interior):

If the removal of cementitious materials is not desired or possible (for example, when backup substrate is glazed brick), the metal lath must be installed directly to the backup substrate. This is done in order to produce a sufficient mortar/epoxy adhesive bond between the backup substrate and thin stone veneer.

For concrete, expansion anchors, screw anchors, and sleeve anchors are all acceptable fasteners for un-cracked or newly placed concrete. For cracked concrete, certain expansion and screw anchors are acceptable, such as HILTI Kwik-Bolt TZ Expansion Anchors and Kwik-Hus EZ respectively. It is important to refer to the manufacturers specifications. If it is unclear whether anchors are acceptable or unacceptable, contact the supplier or a qualified engineer for review.

For grout filled CMU, expansion anchors, screw anchors, and sleeve anchors are all acceptable fasteners. For hollow CMU, screw anchors and sleeve anchors are acceptable fasteners. For brick, screw and sleeve anchors are acceptable for use. When fastening to CMU or brick, check for the integrity of the unit and avoid units that appear damaged. Always fasten the anchor in the center of the unit and avoid fastening at the joints. Always follow manufacturer's instructions for installation.

For ICF installation, details and instructions can vary depending on the ICF manufacturer. Companies such as Nudura, Amvic, and Logix all provide guidelines for installation of various exterior finishes.

Before beginning the installation process, determine which ICF product has been used and always follow the ICF manufacturer's guidelines. If more information is required, contact the ICF manufacturer or a qualified engineer before proceeding.

Metal lath attached to exterior brick veneer.

Table 2: Fastener Spacing for Metal Lath

Lath Type	Nominal Weight lbs/yd² (kg/m²)	Maximum Permissible Horizontal Spacing of Anchors Center to Center in (mm)			
		Wood Studs	Steel Studs	Concrete	CMU/Brick
Diamond Mesh	2.5 (1.4)	16 (406)	12 (305)	16 (406)	16 (406)
	3.0 (1.6)	16 (406)	12 (305)	16 (406)	16 (406)
	3.4 (1.8)	16 (406)	16 (406)	16 (406)	16 (406)
Flat Rib	2.5 (1.4)	16 (406)	12 (305)	16 (406)	16 (406)
	3.0 (1.6)	16 (406)	16 (406)	16 (406)	16 (406)
3/8" Rib	3.0 (1.6)	19 (482)	N/A	N/A	N/A
	3.5 (1.9)	24 (610)	N/A	N/A	N/A
	4.0 (2.1)	24 (610)	N/A	N/A	N/A

- Where plywood is used for sheathing, a minimum of 1/8" (3.2 mm) separation shall be provided between adjoining sheets to allow for expansion.
- Metal plaster bases shall be furred away from vertical supports or solid surfaces at least ¼" (6.4 mm). Self-furring lath meets furring requirements; except, furring of expanded metal lath is not required on supports having a bearing surface of 1 5/8" (42 mm) or less.
- All information references ASTM C1063

For all substrates, lath shall be attached to framing members with fasteners spaced not more than 7" (178 mm) vertically center-to-center along supports.

Step 2: Mortar/Epoxy Adhesive Preparation & Application

Step 2.1: Mortar/Epoxy Adhesive Preparation:

Step 2.1.1- Scratch Coat and Setting Bed Mortar/Epoxy Adhesive Procedure (Exterior & Interior):

Interior Applications:

For interior applications, it is the installer's choice to use special epoxy adhesives instead of mortar (as long as the epoxy is approved for thin stone applications by the Manufacturer). Prepare the epoxy adhesive based on the Manufacturer's instructions. If used, Step 2.2.1 can be skipped. It is not recommended to use adhesives and epoxies near heat sources as they degrade and release carcinogens with increased exposure.

Exterior Applications:

Mortar must be prepared for two different layers of the thin stone veneer system: the scratch coat and the setting bed. A scratch coat is required only when a metal lath is applied to the wall structure. Mortar itself is made up of three different components: cement, sand and water. Portland-Lime and Masonry Cements are the most widely preferred and recommended binders for mortar used on thin stone veneer systems. Both of these cements can be applied into Type N or S mortars.

In order to mix and prepare the mortar for use, provide a large flat and elevated work area such as wheelbarrow. A concrete mixer can also be used to quicken the process. Mix the sand and cement together while slowly adding water simultaneously. Follow the Manufacturer's instructions on mixing ratios for sand and cement. Avoid adding excess water as the mortar will become runny and soupy. If this happens, add more sand and cement to help make the mix more viscid. Continue to mix the mortar until it has a creamy consistency.

Standard products, such as veneer mortar, may also be used as long as they are in accordance with ASTM and CSA standards. Veneer mortars such as Masonbond 400 or QUIKRETE Veneer Stone Mortar (both standard type S mortars) are examples of ready mix products that abide by ASTM and CSA standards and can be used.

As per ACI 530, mortars should be mixed to provide an adhesion shear strength of at least 50 psi (345 KPa) based on gross unit surface area.

It is recommended that the mortar for the setting bed be prepared during the stone placement phase as the stones must be installed before the setting bed is allowed to cure.

Mortar Bonding Agents:

Please note that bonding agents can be added to the mortar to provide additional bond strength for both exterior and interior applications. They are typically used for the following conditions:

- When applying stone for overhead uses such as soffits
- When applying heavy, non-absorptive stones (such as marbles and granites)
- When the builder simply desires a higher bond strength for extra assurance in their installation.

Step 2.2: Mortar Application:

Step 2.2.1 - Apply Scratch Coat (Exterior & Interior):

Once the mortar is fully prepared for the scratch coat, apply a layer over the entire wall using a parging trowel. This layer should sufficiently cover the metal lath. The range of thicknesses required for the scratch coat is 3/8" (10 mm) - 1/2" (13 mm) thick for continuous substrates and 3/8" (10 mm) - 3/4" (19 mm) thick for non-continuous substrates. While applying the mortar, use a bristle brush to roughen up the surface of the scratch coat. At the same time, rake horizontal grooves into the mortar with a sharp tool such as a notched trowel, toothed scraper, or a small piece of metal lath. Before the setting bed can be applied, the scratch coat must be allowed to cure. Depending on the temperature and humidity of the area, curing can take 24 – 48 hours. Visual and physical inspection of the scratch coat is advised before proceeding.

Scratch coat being applied to metal lath.

Step 2.2.2 - Apply Setting Bed (Exterior & Interior):

Interior Applications:

If a special epoxy adhesive is used, apply multiple coats to the wall as a setting bed before any stone is placed onto the wall. The total epoxy adhesive layer thickness behind the veneer stone should be no less than a ¼" (6 mm). It is not recommended to use adhesives and epoxies near heat sources as they degrade and release carcinogens with increased exposure.

Setting bed being applied directly to scratch coat.

Exterior Applications:

After letting the scratch coat cure for a minimum of 24 hours, the setting bed mortar layer is ready for application. Ensure that the scratch coat is dampened using a hose or sponge prior to applying the setting bed. Keeping the mortar wet is extremely important during installation because it helps to keep moisture from being absorbed into the wall itself. It also helps to ensure stronger adhesion between the veneer and the mortar during the stone placement phase.

To install the setting bed, apply a ½" (13 mm) thick layer of mortar directly over top of the backup substrate (if a metal lath is not required) or overtop of the scratch coat (if a metal lath is required) using a masonry trowel. Apply adequate pressure to the mortar during application to ensure a strong bond to the wall.

Step 3: Stone Placement & Joint Finishing

Step 3.1: Stone Placement:

Step 3.1.1 – Conduct a Stone Layout Plan (Exterior & Interior):

Example of good stone layout.

It is recommended that before any stone installation, a placement plan is created for the entire project. Having a plan will help with the coordination and scheduling of the scratch coat and setting bed. This is very important because these mortar/epoxy adhesive layers require time sensitive application and dictate the quality of the veneer installation.

In addition, it is recommended to apply a sample stone layout over a flat area. Arrange the stones as if they were being installed onto the wall. This will help give an idea of how each different size stone fits with each other. It also helps the installer determine the best pattern in which the selected stones can be arranged into.

The bond pattern of the stone should look attractive and aesthetically pleasing. Please note that thin stone veneers are meant to mimic a load-bearing masonry wall. To help maintain this illusion, please avoid the use of very large or small stones. Ensure all stones sizes are within an appropriate range.

Step 3.1.2 - Apply Mortar/Epoxy Adhesive to Back of Stone (Exterior & Interior):

Exterior Applications:

Before applying any mortar to the back surface of the stone, it can be pre-moistened depending on its type. If the stone is more absorptive (e.g. limestone), the back surface should be moistened (be careful to make sure the surface is damp, not wet). However, it is not recommended to pre-moisten stones with low absorption (e.g. granites). These stones do not absorb much water and can potentially leave a wet enough surface that will compromise the bonding strength of the mortar.

Once the stone is pre-moistened, apply a ½" (13 mm) thick minimum mortar layer across the entire back surface of each stone. It is good practice to apply some excess mortar near the stone edges. This will help mortar to squeeze out around the edges when pressure is applied, partially filling the joints as a result. Please ensure that the entire back surface of the stone is covered with mortar. Any voids can lead to water penetration and potentially, premature failure.

Interior Applications:

If a special epoxy adhesive is used, apply an additional layer to the back of each veneer stone if required. This additional amount is only necessary to accommodate areas of the wall with a total epoxy layer thickness less than a ¼" (6 mm). It is not recommended to use adhesives and epoxies near heat sources as they degrade and release carcinogens with increased exposure.

Above and below, examples of applying mortar directly to back of stone. Also referred to as "buttering" back of stone.

Step 3.1.3 - Place and Set Stones onto Veneer System (Exterior & Interior):

Above: Placing stone on prepared wall.

Below: Example of passing stone at inside corners.

Place the stone in the desired location on the wall by applying firm pressure onto the setting bed. The use of a soft rubber mallet can be useful to set the stone into its final place. Be careful to not tap the stone too hard. This can risk shifting and dislodging adjacent stones.

When setting the stones into place, please ensure that all the joint widths are uniform across the entire wall. The required joint width is dependent on the type of veneer stone that is used, as well as the style that is trying to be achieved. As a rule of thumb, keep the joint widths to a maximum of ½" (13 mm) to minimize any shrinkage cracking in the mortar over time.

The installer has the option of starting the stone from the bottom or top of the wall. Starting at the top of the wall will prevent mortar droppings from spilling onto the stones below. Starting from the bottom, however, is beneficial when working with tight fitted joints, where leveling of the horizontal joints is crucial. Working with the stones below will allow the installer to apply a chalk line or level in order to keep the horizontal joint aligned consistently throughout the entire wall.

STEP 3.1.3A – OUTSIDE CORNERS:

When it is time to start setting stone onto the mortar/epoxy adhesive, it is recommended to always start at the corners first. Please ensure to alternate the long and short ends of the corner pieces in order to avoid any long vertical joints. Installing at corners first will give the builder a good starting point to continue the staggered stone pattern across the flat portion areas of the wall.

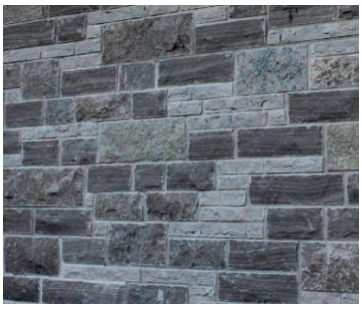
STEP 3.1.3B – INSIDE CORNERS:

At inside corners, it is good practice to alternate passing the stone beyond the outside face of the perpendicular stone at corners of the wall. This will help to give the corner a "weaving" pattern. This arrangement gives the wall a more natural look compared to having a long, vertical joint running up the entire corner.

STEP 3.1.3C- FLAT WALL PORTIONS:

Once all the corners stones are erected, the flat portion stones are ready to be installed. Apply the stones in a staggered pattern and avoid having long continuous vertical joints for more than 3 stone units. The pattern of the stone depends on the type of stone called up for the project. Below are some examples.

Tiger Ledgestone



Aberdeen Valley

Olde Quebec

Step 3.1.4 – Cut and Trim Stones When Necessary (Exterior & Interior):

Cutting and trimming the stones may be necessary to help maintain the wall pattern and joint width. A hand grinder is the most useful and efficient tool to use. Cutting stone is a very dusty process, therefore, please ensure that eye and mouth protection are worn before proceeding. For interior stone installation, it is recommended to cut the stone outside to avoid dust accumulation.

To ensure a smooth and straight cut, it is good practice to mark the cutting line on the stone with a removable marking (e.g. pencil). This will provide a guide line for the installer. Some installers prefer to use a hammer and chisel to break the stone into the desired size. This provides a more natural and rough look around the edges. If using a hammer and chisel, it is recommended to first use a hand grinder and mark a cut line into the stone. The installer can then hammer along the cut line to better achieve the size of stone that is desired.

Before placing any stone onto the wall, please ensure that all dust and residue is removed from stone. This will ensure maximum bond strength between the stone and the mortar/epoxy adhesive.

Above: Wet saw used for thin stone veneer.

Below: Example of cut stone.

Step 3.2: Joint Finishing:

Above: Example of joint grouting.

Below: Example of finished grouting.

Step 3.2.1 - Joint Grouting and Finishing Procedure (Exterior & Interior):

Once all of the veneer stones are set into place, allow the mortar/epoxy adhesive to set for a minimum of 24 hours.

To fill the stone joints with grout, a grout bag or pointing tool (also known as grouting gun) are the easiest and most efficient tools to use. Please ensure that each joint is completely filled and that little to no voids or cracks are present. This will minimize water penetration into the wall over time.

Once the joint has been filled, tool it to the desired finish with a masonry jointer. The type of joint usually depends on the type of stone or a specific request from the Architect or Client.

In Canada, most areas are subject to freezing temperatures. Therefore, it is not recommended to have open joints between veneer stones in areas subject to freeze/thaw cycles. This can cause damage to both the stones and the wall structure itself. Interior applications can have open joints if desired, since this application is not subject to these environmental effects.

Step 4: Cleaning Stone Veneer after Installation

Step 4.1 - Stone Cleaning and Finishing Procedure (Exterior & Interior):

Washing stone with damp sponge prior to finishing.

Once all veneers stones are fully installed and all joints are grouted and finished, there is no doubt that smears and scuffs of mortar/epoxy adhesive would have ended up on the exposed faces of the stones.

When applying cleaning agents to natural stone, it is very important to use the correct product. Using certain chemicals on natural stone can permanently damage their surfaces and affect the visual integrity of the veneer wall. Talk to a local stone supplier for recommendations on what cleaning agents are most appropriate for the type of stone that was installed. It is good practice to test the cleaning agent on one stone before applying it to the entire veneer.

Once the correct cleaning agent is found, use a bristle brush and gently remove any scuffs and smears of mortar/epoxy adhesive off of the stone.

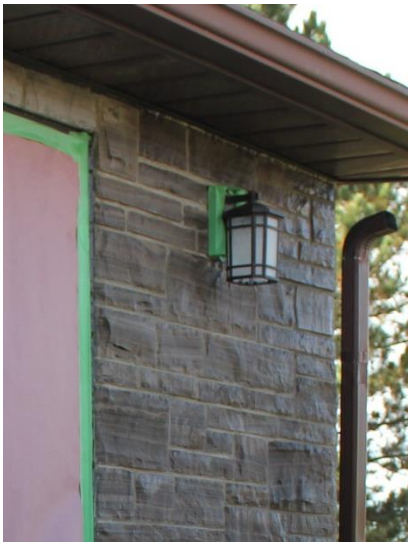
Please note that when using mortar bonding agents, take special care in avoiding any of the agent getting onto the exposed faces of the stones as much as possible. However, these situations are not always avoidable. Talk to a local stone supplier for recommendations on what products can be used to deal with mortar agents. Please ensure that the stone is cleaned as quickly as possible. Mortar agents are very difficult to remove once they have cured.

Step 4.2 – Apply Stone Sealer (Exterior & Interior) - OPTIONAL:

If desired by the Client, a sealer can be applied to the stone veneer to prevent staining. Sealer can only be installed after the mortar has fully cured. This process can take up to 3 or 4 weeks. If sealers are applied, they must be periodically re-applied. Please follow the Manufacturer's instructions when applying any sealer.

Please note that not all sealers work with each stone. If the wrong sealer is used, discolouration of the stone can occur and affect the visual integrity of the veneer wall. Talk to a local stone supplier for recommendations on what sealers are most appropriate for the type of stone that was installed. It is good practice to test the sealer on one stone before applying it to the entire veneer.

For natural stone veneers, water absorption can vary greatly, even when considering stones of similar type. For accurate absorption values, consultation with the stone providers is needed.



Example of applying sealer.

Summary of Thin Stone Veneer System

Summary of Exterior Installation

Continuous Substrate:

1. Treated or untreated backup structure
2. 2.5 lbs. /yd. galvanized metal lath (if backup structure is treated)
3. 3/8" (10 mm)-1/2" (13 mm) thick Mortar Scratch Coat
4. 3/8" (10 mm)-3/4" (19 mm) thick Mortar Setting Bed
5. Stone Veneer and Surrounding Grout

Non-Continuous Substrate:

1. Backup Structure
2. Sheathing
3. Water Resistive Barrier (WRB)
4. 2.5 lbs. /yd. galvanized metal lath
5. 3/8" (10 mm)-1/2" (13 mm) thick Mortar Scratch Coat
6. 3/8" (10 mm)-3/4" (19 mm) thick Mortar Setting Bed
7. Stone Veneer and Surrounding Grout

Summary of Exterior Installation

Continuous Substrate:

1. Treated or untreated backup structure
2. 2.5 lbs. /yd. galvanized metal lath (if backup structure is treated)
3. *OPTION 1:*

a. 3/8"(10 mm)-1/2" (13 mm) thick Mortar Scratch Coat
b. 3/8" (10 mm)-3/4" (19 mm) thick Mortar Setting Bed

4. *OPTION 2:*

a. ¼" (6 mm) thick layer of Approved Epoxy Adhesive

5. Stone Veneer and Surrounding Grout

Non-Continuous Substrate:

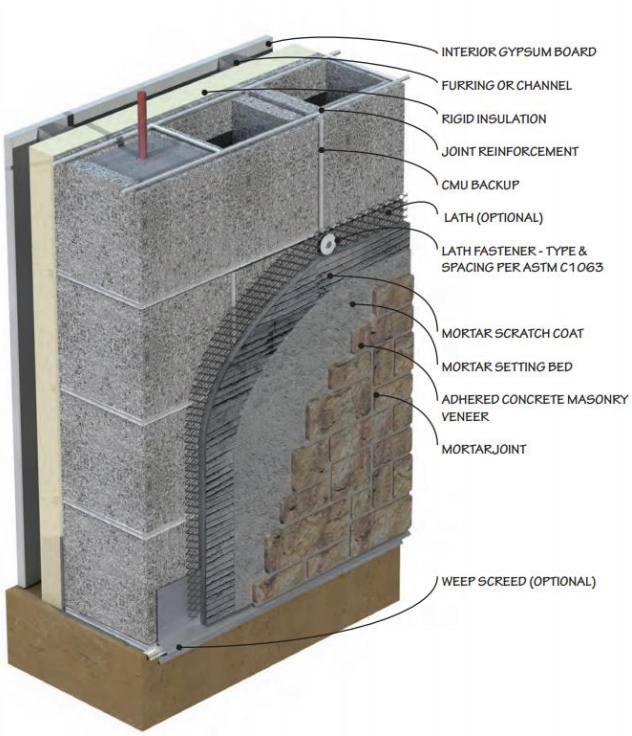
1. Backup Structure
2. Sheathing
3. 2.5 lbs. /yd. galvanized metal lath
4. *OPTION 1:*

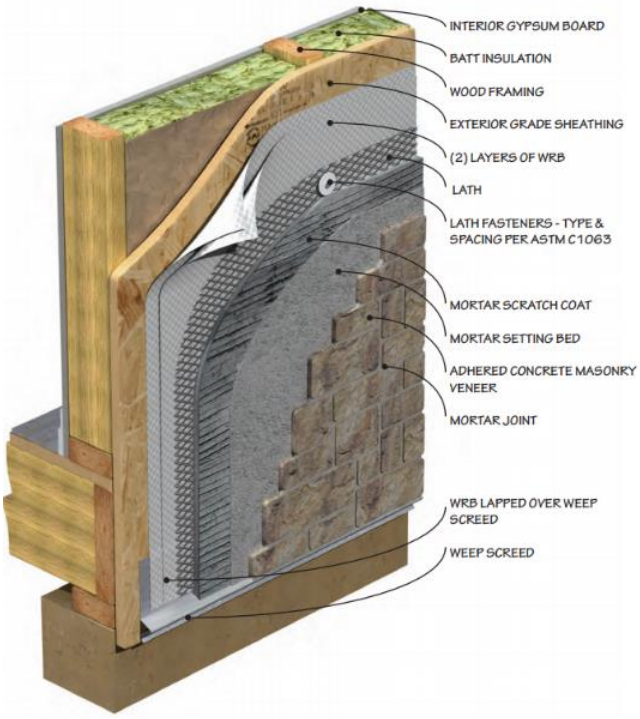
a. 3/8" (10 mm)-1/2" (13 mm) thick Mortar Scratch Coat
b. 3/8" (10 mm) -3/4" (19 mm) thick Mortar Setting Bed

5. *OPTION 2:*

a. ¼" (6 mm) thick layer of Approved Epoxy Adhesive

6. Stone Veneer and Surrounding Grout





Design Considerations and Challenges

Design Considerations:

Deflection Limits & Criteria:

Deflection of a thin stone veneer system is very important to consider when designing the backup structure that will support it. Short and long term deflection will occur due to various factors such as wind loads, large temperature variations (a very important factor in Canada), structural settlement, impact loading etc. Thin stone veneer (as well as mortar) are stiff and brittle materials, therefore making their deflection limits quite stringent. Cracked mortar can lead to issues such water penetration and freeze/thaw damage.

Deflection limits for thin stone veneer vary depending on the code or reference that it is taken from. However, the criteria can also change based on the type of backup structure. For example, steel and wood framing are much more flexible than cast-in-place concrete or CMU, therefore, their deflection limits are stricter.

Deflection criteria from various codes, references and industry groups are as follows:

- **Canadian Handbook on Steel Construction (CSA S16-09 Table D.1) –** requires a deflection limit of **L/400** for storey drift, with special provision to accommodate building frame deformation
- **Design of Masonry Structures (CSA S304.1-04 Cl. 10.14.3**) – requires a deflection limit **L/360** where brittle finishes are attached
- **The Brick Industry Association** – recommends a deflection limit of **L/600** to **L/720** for brick veneer attached to steel backup
- **Canadian Wood Design Manual (CSA 086 Appendix A -4.5.2) – L/360** is recommended to control damage to exterior walls with wood framing with brittle finishes (brick/stucco/plaster)
- **Indiana Limestone Handbook (22nd Edition – Section II, p. 25) –** recommends a deflection limit of **L/600** to **L/720** for masonry cladding set into mortar, to minimize deflection to the mortar joints and resulting leakage.

Mortar Advantages and Disadvantages:

The typical choices of mortar for thin stone veneer systems is ASTM Type N or S. These mortar types can contain either Masonry (MC) or Portland-Lime (P-L) blend cement.

ASTM Type N Mortar:

- Most popular and inexpensive mortar that is used by masons. Easier to prepare and is more workable compared to Type S. Ideal in severe weather or high heat conditions.
- Lower bond strength and cannot be used below grade

ASTM Type S Mortar:

- Provides stronger bond that may be required in areas with high wind or seismic loads. Can also be used below grade to resist soil and groundwater pressures
- Subject to greater shrinkage and cracking due to higher bond strength

Masonry Cement:

- Contains a high air content which provides workability. Air bubbles also provide sufficient freeze/thaw protection because water is allowed to expand inside bubbles during the freezing cycle
- Higher air content reduces bond strength and can cause rapid evaporation of water in mortar preventing complete cement hydration when subject to hot weather

Portland-Lime Blend Cement:

- Provides a higher bond strength
- Higher cost compared to Masonry Cement

Maximum Height of Adhered Veneer Systems:

Maximum height of adhered veneer systems varies depending on the codes and standards referenced. The MIA Dimensional Stone Design Manual specifies a maximum height of 15' (4.5 m) for exterior adhered veneer (Vertical Surfaces, 1.3.1), while the Florida Building code specifies a maximum height of 30' (9 m) (Florida Building Code, 1403.3.3). ACI 530/TMS 402 also notes that differential movement in the building must be accounted for at any height. This is important to consider as the adhered veneer system is rigid and differential movement between floors can cause damage to the system. It is recommended that adhered veneer systems not exceed a height of 30'. Installers should always defer to local building codes and consult qualified professionals for adhered veneer systems which exceed 30'.

Polymer Modified Mortar

Polymer modified mortars are those which utilize different polymers and chemicals to impart different characteristics onto the mortar. The most common type of polymer modified mortar is commonly referred to as thin-set mortar. Utilizing a water retention compound, the cement is able to hydrate with water more efficiently, allowing the installer to apply a much thinner coat (typically 3/16" thick). ANSI A118.1 standards should be followed when specifying and producing thin-set mortar. Standard products are also available for use from various suppliers such as Laticrete, Quikrete, and Masonbond. The advantages and disadvantages of thin-set mortar are listed below.

Advantages

- Cost effective
- Quicker to install

Disadvantages

- Unable to level out unevenness in substrate
- Excess movement in substrate will cause cracking of mortar.

Latex modified mortars are also growing in popularity and utilize other chemicals to change the properties of the mortar further. Depending on the chemicals added, the affected properties of the mortar can include;

- Increased freeze/thaw resistance
- Improved flexibility
- Improved adhesion
- Water proofing

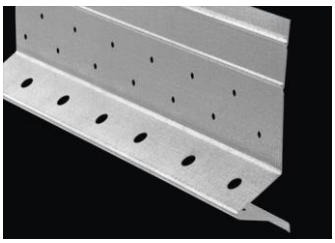
The ANSI A118.4 and A118.11 provide minimum performance levels of latex-modified Portland cement mortars. Standard products from the companies listed above can also be purchased. The supplier of the mortar should be contacted to ensure that a mortar with the appropriate properties is specified.

Water Penetration and Protection:

When constructing a thin stone veneer wall, water penetration into the backup structure is a big design consideration and challenge. The veneer system itself provides remarkable water-resistance however, it is not fully waterproof. Therefore, designers cannot guarantee that the mortar alone will be able to provide water-resistance throughout the entire veneer's service life. Structures containing wood or metal stud framing require a water-resistive barrier over the wall sheathing to help provide additional protection for the backup superstructure. For wood, especially, a protective barrier against moisture and other exterior elements is extremely important to help prevent expansion, contraction, swelling and warping of the structural members. Some local building codes may also call for additional flashing such as weep screeds to help guide water away from the interior areas of the wall.

Cast-in-Place Concrete and CMU walls, on the other hand, provide sufficient waterproofing characteristics. Therefore a water-resistive barrier is not required unless otherwise stated by local building codes.

In areas where constant wetting occurs such as window/door sills, headers or wall bases, water repellent treatment is recommended to prevent moisture penetration over time. It is important to ensure that non-breathable treatments such as acrylic and elastomeric sealers are not used. These types of treatment help to prevent external inflow of moisture, however, it traps existing moisture on the stone which can result in further damage. Breathable treatments that are siloxane and silane based will help prevent this issue.



Weep Screed

Asphalt Felt Water-Resistive Barrier

The thin stone veneer system is subject to movement over time due to factors such as impact and vibration loads, building settlement and changes in temperature and humidity. These movements can produce ongoing cracking in the stone joints. To prevent this issue, compressible movement joints must be applied. Movement joints should have a minimum width of 3/8" (10 mm) and should be filled with compressible material such as sealant and backer rod.

Typical locations for movement joints are at building openings (window and doors), where the veneer meets another cladding material and near building corners. For large, unobstructed walls, movement joints will need to be applied at a certain spacing depending on the coefficient of thermal expansion of the veneer stone. Please check with local building codes and/or a local architect/project engineer to determine the full requirements for movement joints.

Applying Thin Stone Veneer over Cement Board in Interior Applications:

To help reduce material and installation cost, cement board can be substituted for both the water-resistive barrier (if required) and metal lath for non-continuous substrates in interior applications only.

Install the cement board (ensure the rough side is facing out to provide sufficient adhesion for the veneer stone) directly over the framing or sheathing. Similar to the metal lath, install fastening screws or nails at a maximum horizontal and vertical spacing of 16" (406 mm) and 6" (152 mm) O/C, respectively. To ensure sufficient load transfer into the structural framing, the fasteners should have a minimum penetration of 1" (25 mm) for wood framing and 3/8" (10 mm) for steel framing. Use fiberglass tape to seal the board joints and seams.

Once the cement board is placed, apply the mortar or epoxy adhesive in the same process as if applying it over a metal lath. Please note that if a Portland-Lime blend cement is used, a bonding agent is recommended to provide sufficient bonding strength for the mortar.

Applying Thin Stone Veneer over Rigid Insulation:

To achieve greater thermal efficiency for buildings, designers and manufacturers are recommending application of thin stone veneer systems directly over rigid insulation. However, in the opinion of PICCO Engineering, rigid insulation is too much of a compressible material to sufficiently transfer load from the veneer stone to the backup structure. Therefore, this installation approach will not be endorsed. If rigid insulation is absolutely desired, special provisions must be accounted for in the design. Please consult with a local engineer/specialist for these provisions.

Special Conditions and Challenges:

Wall Caps/Retaining Walls:

Walls Caps and Coping Stones are a key finish for any free standing thin stone veneer wall. Please ensure the edge of each cap stone extends 1"-2" beyond the front face of the vertical veneer stone. This will help provide an aesthetically pleasing finish. In addition, a drip edge can be grinded onto the underside of the cap stone to help prevent water from travelling to the stone joint and stone faces below. Another option to prevent this issue would be installing weep hole flashing directly underneath the cap stone.

When installing coping and cap stones, ensure a minimum ½" thick full bearing mortar bed is applied over the top of the backup structure surface. Ensure that all mortar joints between stones is thoroughly filled to minimize water penetration.

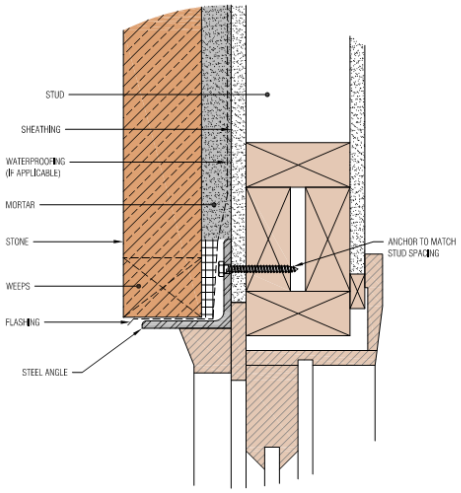
When installing thin stone veneer over retaining walls, special provisions must be taken to minimize water penetration and maximize drainage. Refer to local building codes to determine water and damp proofing requirements. In addition, ensure that proper drainage is applied as well whether it be a drainage mat and/or additional flashing (refer to local building codes to determine criteria for adequate drainage).

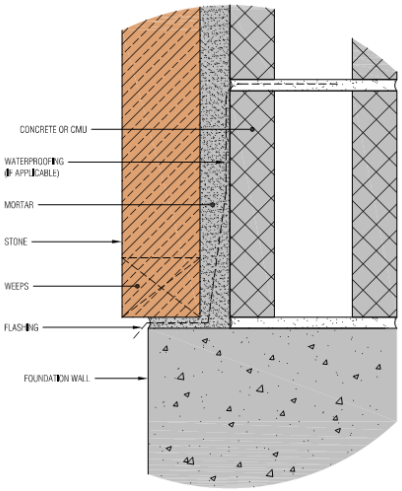
Installing Oversized Banding & Window Sills:

For almost all projects involving thin stone veneer, banding stones, water tables and/or window sills will be used. Generally, these stones are thicker than the 2-5/8" (67 mm) limit that is allowed for adhered stone (As stated by the MSJC and MIA). According to these standards, once this thickness is exceeded, the bonding capacity of the mortar/epoxy adhesive alone is not considered sufficient to carry the weights of these stones. Therefore, steel support angles anchored to the backup structure must be provided to bear the gravity loads from these stones. The Project Engineer designing these steel angles has the option of providing continuous or local members. The Engineer should keep in mind that at least 2/3 of the stone's base depth must rest directly onto the steel. This will ensure sufficient load transfer from the stone to the angle, as well as prevent any possibility of the stone overturning due to its own weight in combination with wind and seismic loads.

Installing Veneer above Openings:

For any veneer that rests above an opening and does not span to rest on the adjacent veneer, lintels to support the weight of the stone should be provided. Lintels can be either steel angles or gauge material bent into the appropriate shape. The lintel must be designed to carry the load of all of the stone above an opening, provide bearing of at least 2/3 the thickness of the stone, and should be attached to the substrate behind (studs, concrete, etc.). For exterior applications, lintels should be made of non-corrosive materials such as stainless steel, galvanized steel (hot-dipped is recommended), or aluminum. If staining due to rust is an issue, provide separation between the stone and lintel with shims or a barrier. As the thickness, density, cavity, substrate, and height of stone being supported are all variable, lintels should be sized on a project by project case by a qualified engineer. For base course stone, a solid ledge such as a foundation wall should be provided for the stone to bear on. A bearing of 2/3 the thickness of the stone should be provided. General details for lintels can be found below.

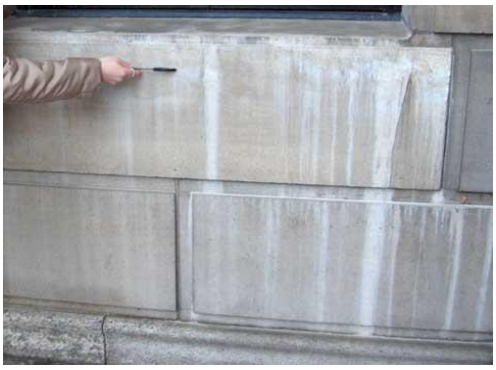




Efflorescence:

Efflorescence is the movement of salt to the surface of a porous solid (such as stone and mortar). Moisture that has penetrated into the stone and/or the mortar joints dissolves the existing salts into a water-based solution. This solution then migrates to the stone surface where water then begins to evaporate. Once this process is complete, a white, chalky power is left over and rests on the face of the stone and/or mortar.

Efflorescence is an indicator of moisture penetration. Mitigating this infiltration at its source is the most effective solution, however, achieving this is not realistic due to thin stone veneers not being fully water and damp proof in nature. Therefore, periodic removal of the powder will need to be conducted. Use a soft bristle brush (do not use a wire brush, due to risk of scratching the stone face) with clean water to clean off any residue. For difficult deposits, apply a weak acid (such as vinegar). Scrub thoroughly, and immediately rinse off with clean water.



Typical Examples of Efflorescence

Maintenance:

The durability and beauty of thin stone veneer are only some of the reasons why it is such a popular choice in the building envelope and cladding market. However, like any material, it must be properly maintained in order for it to provide long-lasting performance while maintaining its attractiveness. Common examples of maintenance issues and solutions are outlined as follows:

- **Dirt, Dust, Stains and Graffiti:** Loose materials such as dust and dirt can be removed easily by spraying water over the stone face and cleaning it with a rag or cloth. For removing harder materials such as stains and graffiti, it is important to ensure that gentle abrasive cleaning methods be used to avoid any scratching of the stone surface. For example, the use of wire brushes or high pressure mechanical methods such as sand or water blasting should not be considered. A bristle brush used with clean water is an example of a gentle non-abrasive method. If water itself is not sufficient to clean the stone face, consult with a local stone supplier to determine what types of cleaning solutions are suitable.
- **Mortar Joint Cracking:** Overtime mortar joints are susceptible to cracking due to building settlement, thermal expansion and contraction due to drastic changes in temperature (significant issue in most regions of Canada) and impact loads. To help minimize water and moisture penetration, it is good practice to periodically fill joint cracks as required.
- **Minimize Moisture Exposure:** To prevent moisture saturation on the stone and mortar, ensure that the wall contains proper drainage. Inspect all eaves troughs and downspouts to confirm that they are installed and aligned appropriately. Also, any external landscaping features such as sprinklers should be directed away from the wall as much as possible. Lastly, vegetation growth on the stone is also a significant source of moisture and should be removed as much as possible (unless it is absolutely desired for aesthetic purposes).