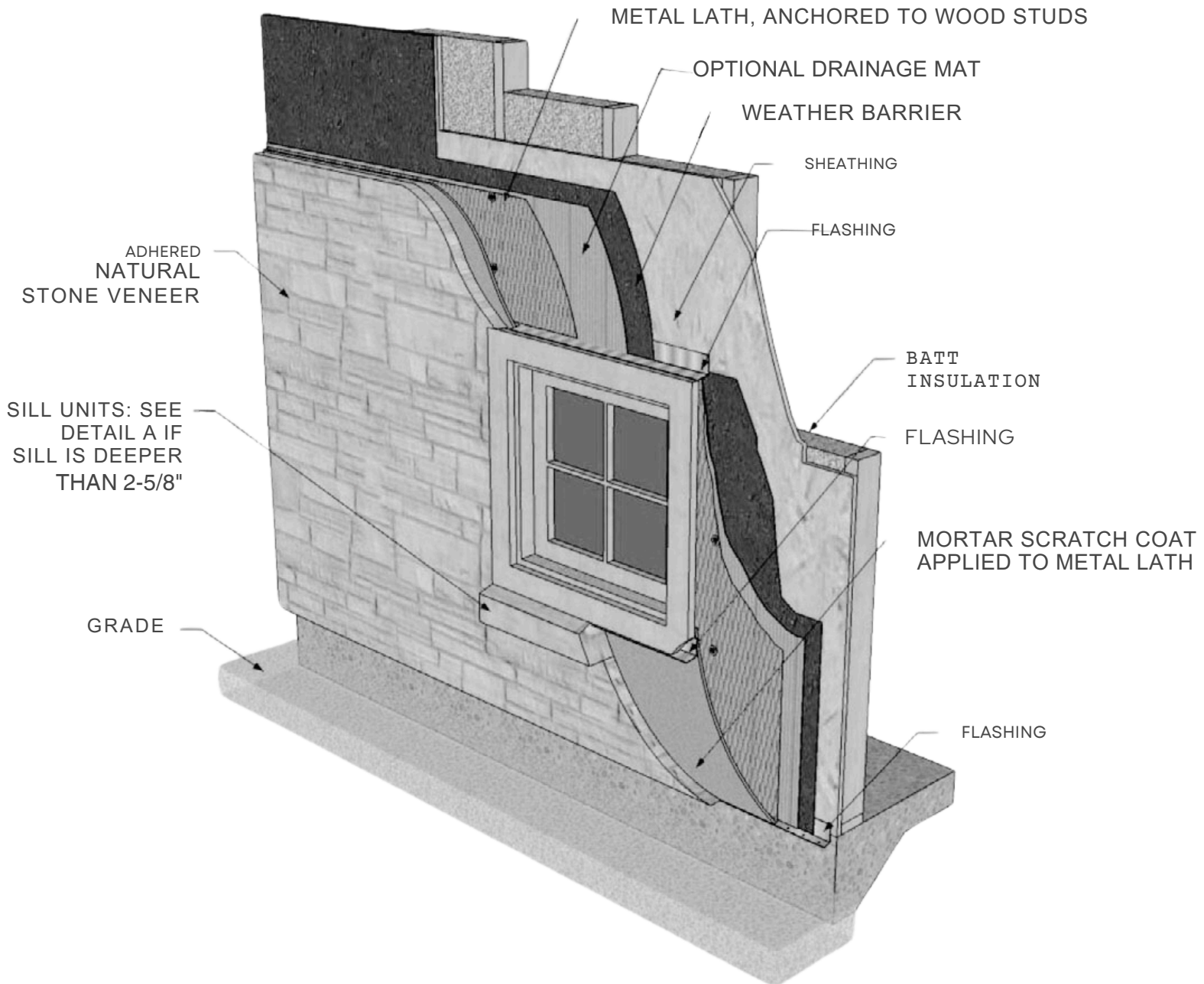
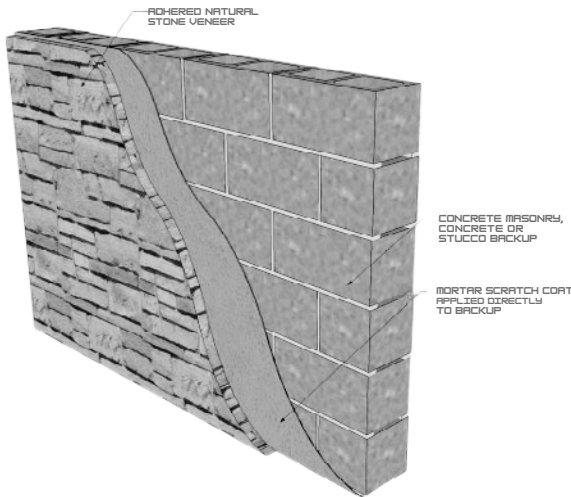


Natural Stone Veneer Installation Guide



Preparing the Backup Surface for Mortar Application

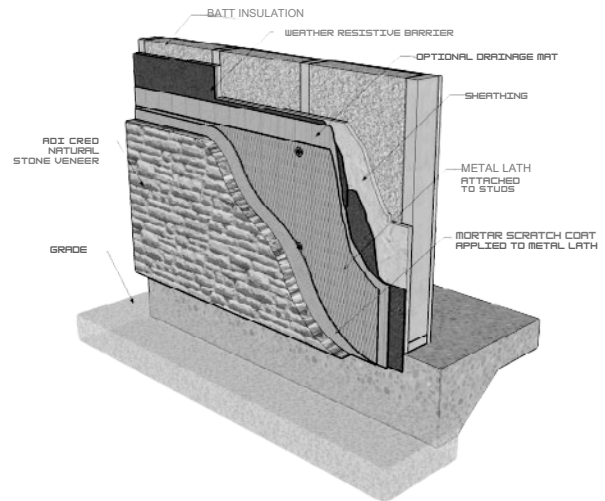
Concrete/Concrete Block/Cementitious Stucco



1A Ensure that concrete, concrete block, or stucco surfaces are clean and in their original, untreated state. If treated, consider light sandblasting or waterblasting to restore the wall to a smooth, untreated surface. Remove any form-release agents, dust, or other substances that might hinder mortar adhesion.

1B Alternatively, securely fix metal lath to the wall at intervals of 6 inches and apply a scratch coat of mortar measuring 3/8 to 3/4 inches in thickness. Use a toothed scraper, notched trowel, or small piece of lath to create light horizontal grooves on the scratch coat. Allow the scratch coat to cure for at least 24 hours before installing natural thin veneer.

Metal or Wood Stud Backup



1. Cover the studs with sheathing, which may include exterior OSB, plywood, exterior-grade drywall, wallboard, or cementitious board.
2. Secure the building paper onto the sheathing in horizontal strips, starting from the bottom and overlapping by 2 inches similar to shingles. Ensure a minimum 6-inch overlap at vertical joints. If employing flashing or support brackets, install them before moving to the next step.
3. Affix the metal lath to the studs using screws, staples, or nails. Ensure a minimum overlap of 1/2 inch for horizontal joints and 1 inch for vertical joints. Around corners, overlap vertical joints by at least 16 inches to prevent corner cracking. Use barbed galvanized nails at 6 inches on center vertically for exterior applications or steel wire furring nails at 4 inches on center for interior work. Ensure a minimum nail penetration of 1 inch into the studs. For steel studs, anchor the lath with corrosion-resistant screws having a minimum shank diameter of 0.136 inches.
4. Apply a scratch coat with a thickness of 3/8 to 1/2 inch over the metal lath, embedding it. Employ a toothed scraper, notched trowel, or small piece of lath to create light horizontal grooves in the scratch coat. Allow the scratch coat to cure for at least 24 hours before installing adhered stone.



Fig. 1A - Attaching Lath



Fig. 1B - Applying scratch coat

Mortar Application and Stone Placement

Starting Point

You have the option to begin laying stones either at the top or the bottom of the wall. Starting from the top and working downward might prevent mortar droppings from staining stones below. However, ensure that the mortar is sufficiently robust to support the suspended stone in position.



When starting from the bottom, employ a straight-edge and initiate 4 inches above soil level or 2 inches above concrete to prevent moisture absorption from the ground. If corner pieces are necessary for your wall, prioritize placing these stones first. Once your corner pieces are set, proceed with the field stones.

Mortar Application

At the start of each workday, dampen the entire surface of the wall with a sponge or hose. This prevents the wet mortar from being absorbed too quickly. Re-moisten your working area every hour with a fog spray or wet brush, aiming for a damp but not overly wet environment.

Using a trowel, apply mortar ranging from 3/8 inch to 3/4 inch thick onto your designated work area. Firmly press the mortar layer onto the backup wall (for concrete, concrete block, or stucco) or into the scratch coat (for studs). Limit your working area to approximately 10 square feet to ensure the mortar doesn't set before you can place the stones.



Setting Stones

Before placing absorbent stones such as sandstone and certain types of limestone, it's advisable to lightly mist or brush the back of the stone with water, ensuring it's damp but not soaked. However, avoid pre-wetting dense granites or other stones with less than 1% absorption, as they won't adhere well to saturated surfaces.

Just before positioning the stone, completely cover the entire back surface with 1/2 inch of mortar. Apply a slightly thicker layer of mortar around the edges of the stone. This excess mortar will allow some to squeeze out from the edges when pressure is applied, filling the joints.

Once the stone is firmly pressed into the mortar bed, gently tap it with a soft mallet to secure it in place, taking care not to tap too forcefully. In some cases, tapping on stud systems could cause adjacent stones to shift. Avoid disturbing or tapping the stone once it's set. The total thickness of mortar behind the stone should range from 3/8 inch to 1 1/4 inches.

Joint Width

The appropriate width of joints depends on both the type of stone utilized and the desired aesthetic outcome. Wider joints may necessitate additional mortar on the back of the stone, while thinner joints require less mortar. However, it's important to note that increasing the mortar volume on the stone's back can lead to mortar droppings on the stones below and add extra weight, potentially causing stones to become too heavy and detach from the wall.

Maintain uniformity in joint width to ensure consistency. Joints wider than 1/2 inch may result in shrinkage cracks within the joint.

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Cutting and Trimming Stones

When positioning a stone, aim to select one that harmonizes well with its adjacent stone. Some stones may require trimming to ensure a snug fit and consistent joint widths. To trim the stone, utilize either a handheld grinder equipped with a diamond cutting wheel or a chisel and hammer.

For a more rustic finish, score the back of the stone using the grinder, then break off the excess pieces with a hammer. After cutting and trimming the stone, thoroughly remove any grinding residue and dust using a sponge or brush.



Grouting and Finishing Joints

Once the stone is securely positioned and has been set for 24 hours, return to fill the joints using either a pointing tool or a grout bag. This final joint-filling step is crucial for enhancing the wall's resistance to moisture penetration. Utilize a concave joint tool to compress and smooth the joints thoroughly, ensuring maximum water resistance. Unlike rough-cut or raked joints, tooled joints offer superior water resistance. After tooling the joint, brush away any debris or mortar tags.

It's important to note that installing stone veneers with open joints outdoors in regions experiencing freeze/thaw cycles is not recommended due to potential issues. However, dry stack installation can be suitable for interior applications or in warmer climates where freezing is not a concern.

Clean up at the End of the Day

At the conclusion of the workday, delicately remove any mortar smudges from the stone using a soft brush. Avoid employing aggressive high-pressure cleaning techniques, as they could potentially dislodge the stone. While natural stone is generally resilient to many chemicals, certain cleaners have the potential to harm the stone's surface. Consult your stone supplier for precise recommendations tailored to the cleaning needs of your specific stone.

Workmanship

Installing adhered natural stone veneer may seem straightforward, but it demands a skilled tradesperson with an artistic eye to arrange the stones in an appealing manner. Several crucial workmanship considerations include:

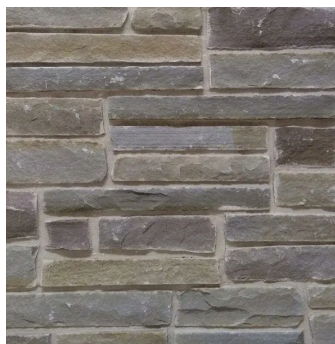
- Ensuring complete mortar bedding at the back of each stone is imperative. Even minor voids can accumulate water over time, leading to premature failure.
- Mortar joints must be adequately filled and well-tooled to prevent water infiltration into the wall. Dry-stack patterns are ill-advised for exterior use in regions with harsh climates characterized by frequent freeze/thaw cycles, such as Colorado.
- Maintaining a fairly uniform mortar joint width is essential. Excessively wide joints may develop shrinkage cracks, while narrow joints can be challenging to fill properly.
- The bond pattern should appear "comfortable," avoiding the use of occasional large or very small stones or thin vertical pieces. The final result should emulate the appearance of load-bearing masonry, as depicted in various typical stone patterns.
- Continuous vertical mortar joints that span more than four units should be avoided to maintain structural integrity.



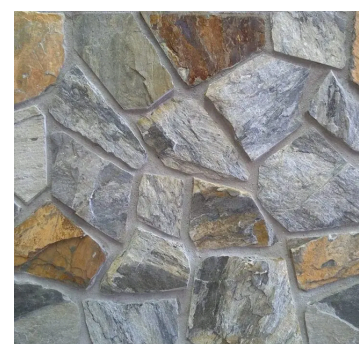
Ashlar



Cobblestone



Ledgestone



Mosaic

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Interior Uses

In most interior stone veneer installations where moisture exposure is not a concern, preventative measures against water penetration are unnecessary. For dry interior applications, thin stone can be affixed to the backup wall using mortar or specialized epoxy adhesives sanctioned for thin stone usage. In such scenarios, the weather resistive barrier is redundant.

Acceptable types of backup walls for interior applications encompass concrete, Concrete Masonry Units (CMU), brick, and Cementitious Board over studs.

To apply the thin bed of adhesive over these backup walls, start with the flat side of the trowel. Follow up with an additional coat of adhesive using the notched side of the trowel. Subsequently, position the stone, ensuring adequate coverage and bedding by applying adhesive to the stone's back if necessary. Once firmly pressed into the adhesive bed, use a soft rubber mallet to set the stone. The total adhesive thickness behind the stone should measure at least 1/4".

Mortar/Adhesive Pros and Cons

Type N vs. Type S Mortar

- Type N mortar is a versatile option suitable for various applications. It offers enhanced performance in hot weather conditions and is generally easier to work with.
- Type S mortar boasts a stronger bond, yet this heightened bonding capability may lead to increased shrinkage and potential cracking. Some building codes, particularly in seismic regions, may mandate the use of Type S mortar.

Portland-Cement-Lime (PCL) vs. Masonry Cement (MC)

- PCL offers a superior bond and is recommended for use whenever feasible.
- MC, favored by many masons for its improved workability, possesses a weaker bond strength due to its elevated air content. Additionally, it retains less water, leading to quicker mortar dry-out when employed in hot weather conditions.

Mortar Bonding Agents

Bonding agents are added to mortar to enhance its bond strength. They are typically unnecessary if proper application procedures are followed. However, some installers use bonding agents as extra "insurance" to prevent call-backs. When using these high bond mortars, take special care to keep the wall clean, as the droppings become difficult to clean once cured. Consult your stone supplier for recommended bonding agents for your specific stone.

Adding a bonding agent to your mortar can be beneficial in the following scenarios:

- Soffits or other overhead applications.
- When installing non-absorptive, high-density stones (such as granite or marble) with smooth cut surfaces.

Structural Backup Wall

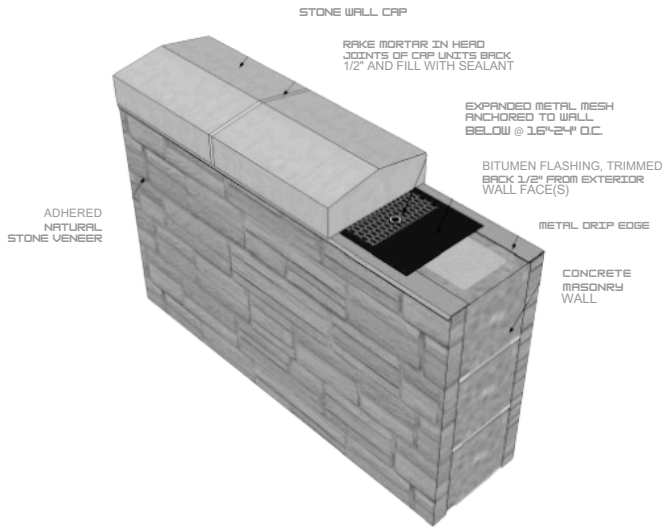
Adhered natural stone veneer is an attractive wall covering, but the structural backup behind the veneer is crucial for resisting loads. According to section 6.3.2.3 of the MSJC, the backup wall can be made of wood framing, steel framing, concrete block, or poured-in-place concrete.

With adhered applications, the stone veneer will move with the backup wall as the structure responds to loads, temperature changes, and soil settlement. Natural stone veneer is relatively stiff and pairs well with concrete block or poured-in-place concrete backup systems. In contrast, wood and steel framing are more flexible. Choosing a stiff backup structure can help prevent future cracking of the adhered veneer. Wood framing is particularly prone to movement as it swells in damp conditions and shrinks when it dries.

Narrow cracks in the mortar may appear over time as the backup wall moves. Water entering these cracks can cause premature failure. While slight cracks due to movement usually do not compromise the integrity of the stone veneer, they should be filled with new mortar to keep moisture out of the wall system.

Special Considerations

Wall Caps



Wall caps require special attention due to their many exposed mortar joints, which are prone to moisture penetration and can accelerate the cap's deterioration. To prevent water from seeping into the wall beneath the cap, use through-wall flashing with weep holes directly below the wall cap. An even better solution is to use a precast concrete or monolithic stone cap.

Deflection Limits

Although adhered natural stone veneer isn't expected to carry structural loads, it is an inherently stiff material. When installed over stud framing, the adhered stone veneer can be much stiffer than the backing material used for structural support. As the structure responds to loads, temperature variations, and structural movement, the stone veneer will move with the backup wall. Some applications of adhered stone veneer over conventional wood or steel stud frame construction have experienced cracking due to deflection of the stud wall.

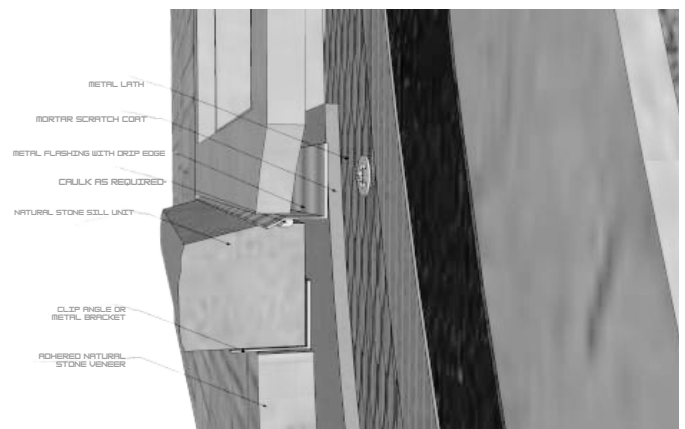
The relatively stiff natural stone veneer is well-matched to a concrete block or poured-in-place concrete backup. In contrast, wood and steel framing are relatively flexible. Wood framing is particularly susceptible to movement as the wood swells during damp periods and shrinks when it dries. Designers of steel and wood stud backup systems should consider backup stiffness in their design and use heavier studs or tighter stud spacing to reduce the potential for veneer cracking.

Oversized Window Sills

MSJC 6.3.2.1 limits the thickness of all adhered masonry veneer to 2-5/8 inches, measured horizontally as installed. Any stone deeper than this limit exerts an eccentric load on the wall that exceeds the capacity of the bonding mortar to hold it in place. Stones thicker than 2-5/8 inches must be installed as anchored veneer.

Window sills are often made from pieces of wall stone installed horizontally instead of vertically, and these sills frequently exceed the code-allowed depth. Their gravity loads must be supported by steel angles. These angles do not need to be continuous or particularly heavy, as they are not supporting much weight. However, the clip angles must be large enough to support two-thirds of the depth of the sill. A clip angle at each end of each piece of sill stone should suffice.

Consult your project engineer to design the appropriate clip size, spacing, and anchorage to the backup structure.



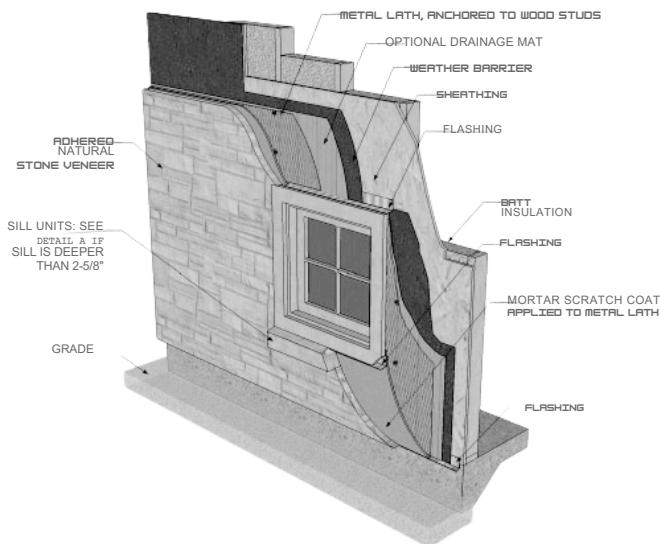
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Flashing/Water Penetration

Masonry veneers are water-resistant, not waterproof, regardless of construction quality. They effectively resist moisture penetration but still require a moisture-resistant covering on the backup wall to prevent water damage. For wood or steel stud walls, install building paper as a moisture barrier over the sheathing. Concrete block and poured-in-place concrete are sufficiently water-resistant and do not require an additional moisture barrier. Use flashing at the base of walls, at sills, and under wall caps to direct any moisture to the exterior face of the wall.



Flashing/Water Penetration

Most natural stone veneer applications are inherently weather-resistant and do not require ongoing treatment. However, in certain instances, water repellent treatments can help the wall resist moisture penetration and staining. It may be beneficial to apply water repellent in areas prone to constant wetting, such as the base of walls, sills, and caps. Ensure that you use a breathable water repellent with a silane or siloxane base. These products penetrate the surface of the veneer to shed water while allowing water vapor from within the wall to escape. Avoid elastomeric or acrylic sealers that form a film on the wall surface, as non-breathable films can trap water in the wall, leading to long-term damage.

Efflorescence

Efflorescence is a white, powdery deposit that sometimes appears on the surface of masonry walls. Natural stone rarely exhibits this chalky deposit, but manufactured stone, which is made with cement, is very absorbent and often shows efflorescence. You may also notice slight efflorescence from the mortar joints if the veneer is installed in an area that occasionally becomes saturated.

Efflorescence is generally not harmful but indicates excessive moisture exposure. Remove powdery deposits by brushing; harder carbonate deposits may require scrubbing with a weak acid dissolved in water. By eliminating the source of moisture, efflorescence will not recur.

De-icing salts are a common cause of efflorescence, scaling, and corrosion of metal lath. Efflorescence may appear in the splash zone or at building entrances, where stone can wick salt-rich moisture from adjacent sidewalks or paving areas.

Durability and Maintenance

Natural stone has very low absorption, high strength, and excellent resistance to weathering, providing long-lasting performance if you follow these simple guidelines:

- Prevent excess moisture from saturating the wall by adjusting landscape sprinklers, downspouts, and other water sources to avoid constant wetting.
- Periodically remove any vegetation such as ivy or moss.
- Clean with a gentle water spray to remove dust and dirt. For stains, graffiti, or other serious cleaning issues, use gentle methods to avoid damaging the mortar and stone. Consult your local stone supplier for the best cleaning solutions and always test any solution on a small area first.
- As buildings shift and settle, cracks may appear. Repoint cracks with new mortar to restore the wall's natural weather resistance.

Refer to the Table on the following page for a comparison of the properties of natural and manufactured stone.

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Natural and Manufactured Stone Property Comparison

Stone type	Min. Compressive Strength ¹ , psi	Max. Water Absorption by Weight ² , %	Thermal Expansion ³ , in/100°f/10ft	Shrinkage (-) and Expansion (+) ⁴ , in/10ft	Freeze-Thaw Durability
Natural Stone	1,800 to 20,000	0.2 to 12	0.0264 to 0.0804	(+) 0.00048 to 0.012	Good to Excellent
Manufactured Stone	1,500	13 to 29	0.0432 to 0.0744	(-) 0.054 to 0.084	Poor

1 Natural Stone includes Sandstone, Limestone, Marble and Granite

2 ASTM Requirement values for Natural Stone; ICC Acceptance Criteria for Artificial Precast Stone Veneer; Max. weight for adhered veneer is 15 psf per MSJC/IBC

3 Expansion in inches per 10 ft section for a 100° F temperature increase. "Conservation of Historic Stone Buildings and Monuments," National Materials Advisory Board

for Natural Stone; "Reinforced Concrete : Mechanics and Design," James G. MacGregor for Concrete (Manufactured Stone)

4 Shrinkage and Expansion in inches per 10 ft section. Natural stone usually expands over time due to moisture uptake; manufactured stone always shrinks over time due to drying and carbonation.

Installing over Rigid Insulation

To achieve good thermal performance, many designers are incorporating a continuous layer of rigid insulation in exterior walls, with some building codes even mandating it. However, these codes don't specify where this insulation layer should be installed.

We recommend adding the rigid insulation to the inside face of the wall when using adhered stone for the exterior veneer. Placing the insulation board between the sheathing and the stone veneer can potentially destabilize the wall structure, as insulation lacks rigidity. While some manufacturers suggest applying adhered stone veneer directly over metal lath installed on rigid insulation instead of sheathing, we advise against this. Rigid insulation is too compressible to provide a suitable substrate for adhered veneer. The pressure from even a ladder leaning against the wall can crack the stone veneer if the substrate compresses.

Rigid foam board cannot directly transfer the weight of the adhered stone veneer to the stud backup or foundation. It relies on fasteners passing through the insulation and attaching to the studs for load transfer. However, the addition of foam introduces a bending component to the fasteners not present when lath is attached directly to the studs. The thicker the foam layer, the more extreme this bending component becomes. If such an installation cannot be avoided, consult an engineer to design appropriate lath anchors to prevent sagging or racking that could lead to cracks in the veneer.

Scuffing

Due to its homogenous nature, natural stone maintains consistent color throughout, making it less susceptible to scrapes and scuffs compared to manufactured stone, which often has a thin, pigmented exterior. For minor scrapes and scuffs, start by attempting simple cleaning or gentle scrubbing to conceal the blemish. Alternatively, you can use a hammer and chisel to resurface the stone, restoring its original texture.

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Movement Joints

Natural stone is generally stable and does not move on its own. However, all buildings experience slight movement over time due to various factors such as applied loads, foundation settlement, traffic vibrations, and changes in temperature and humidity. This movement can sometimes lead to cracks in the veneer unless movement joints are incorporated into the design.

Key locations for incorporating movement joints include:

- Near building corners
- At window and door openings (use a movement joint at one side of an opening 6 to 12 feet wide; openings over 12 feet wide need a joint at each jamb)
- Where the stone veneer meets another material such as siding or stucco
- Approximately every 35 feet on center for large walls without openings

It's crucial that movement joints are flexible. Leave a 3/8-inch gap through the veneer and fill it with backer rod and sealant to accommodate movement.

Retaining Walls

Stone veneers used to face retaining walls, surround swimming pools, and in splash zones near roadways require special attention to detailing and installation. Ensure proper drainage and damp-proofing measures are in place to mitigate moisture issues.