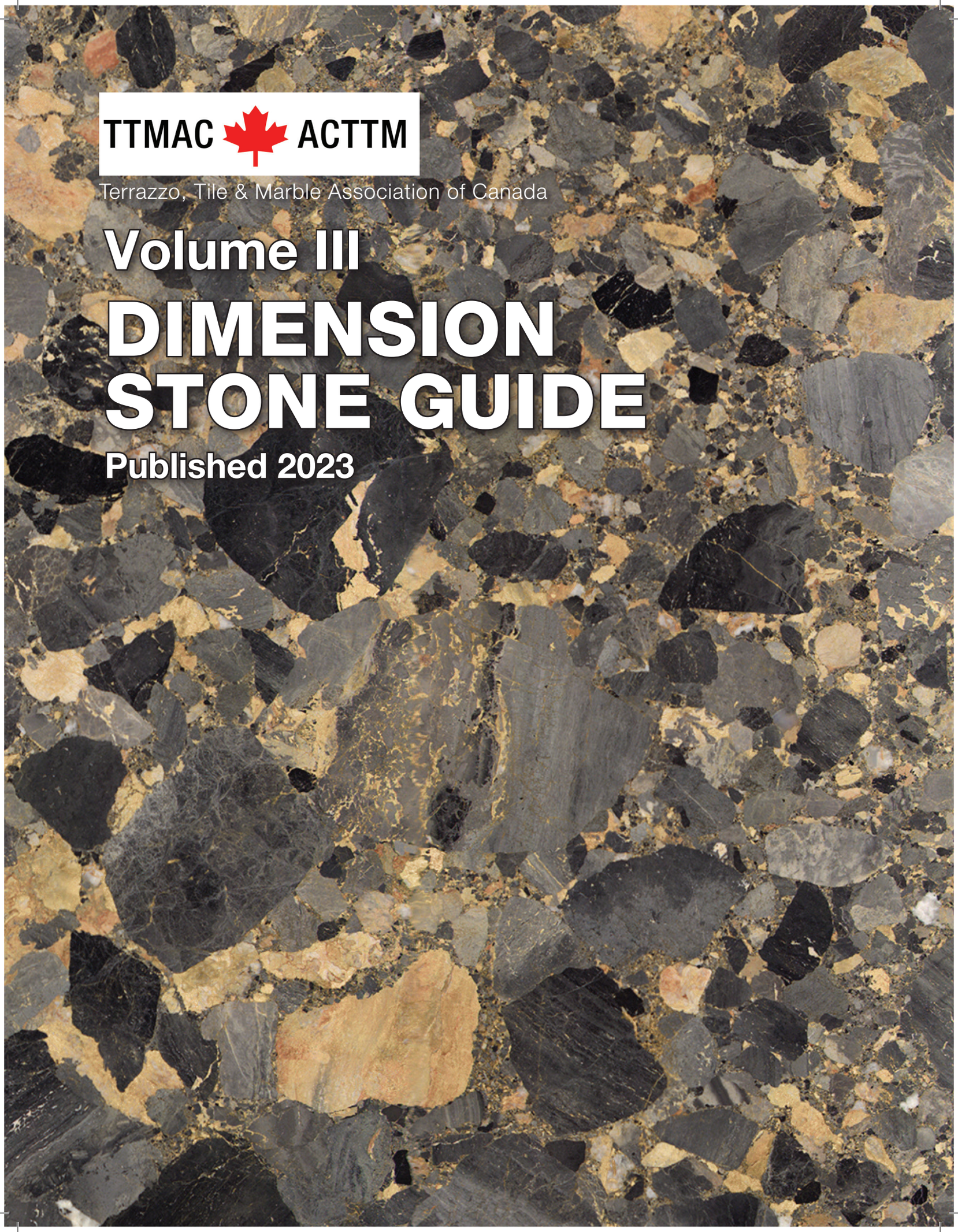
TTMAC ACTTM
Terrazzo, Tile & Marble Association of Canada
Volume III
DIMENSION STONE GUIDE
Published 2023

TTMAC ACTTM

Profile of TTMAC

The Terrazzo, Tile and Marble Association of Canada was founded in 1944. Its mandate was to develop a method of standardizing terrazzo, tile and stone installation techniques, as well as being a technical resource and liaison for architects, designers, engineers and trade installers. TTMAC honours this commitment today as well as many other services and support of the hard surface industry and its members.

Association Activities & Benefits

- Produces and distributes trade specification guidelines.
- Sets standards for installation methods used in the industry.
- Promotes technical research on new materials and techniques.
- Maintains an up-to-date library resource centre.
- Encourages development of new technology and products.
- Is a door to the industry in Canada with a global outlook.
- Publishes newsletters, maintains and circulates an annual Membership Directory and Buyers' Guide.
- Liaisons with other associations, government departments, trade magazines, trade commissions, and those interested in sharing information for the good of the industry.
- Promotes an annual convention, seminars and workshops.
- Provides general information to architects, specifiers, engineers, contractors, designers and the building industry in general.
- Encourages and promotes the installation of terrazzo, tile, natural stone and other dimension stone products and related materials.
- Promotes quality workmanship and materials from TTMAC members.
- Assists in setting training standards and distributes information to further develop training in the hard surface industry.
- Universal floor tester
- Provides ongoing product seminars
- HardSurface Magazine

Specification Study on Stone

The Terrazzo, Tile and Marble Association of Canada provides this Dimension Stone Guide to assist in clarifying and standardizing installation specifications for stone and related products.

It is the responsibility of the architect/specifier or qualified consultant to clearly specify in detail the requirements for the complete installation of stone products, systems, related sections, warranty and guarantees.

This guide refers to the usual circumstances relating to stone installations. In case of circumstances out of the ordinary, we suggest that you consult your Manufacturer, Supplier or Contractor. The scope of work and methods of installation may vary by site conditions and from region to region.

The Terrazzo, Tile and Marble Association of Canada do not accept liability for the information presented by this document. Readers are expected to make judicious use of the data in the guide as part of their quest to further their knowledge.

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This specification guide has been prepared by the technical committee to assist industry professionals with the installation and preparation of specifications as they pertain to dimension stone. His invaluable experience, dedication and assistance are greatly appreciated by the TTMAC.

Master Specifications included in this document have been provided with the consent of Construction Specifications Canada (CSC). Their support of the TTMAC is greatly appreciated.

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TTMAC SPECIFICATIONS AND GUIDES

Specifications Guide 09 30 00 Tile Installation Manual

Tile installer Technical Handbook

Hard Surface Maintenance Guide

09 66 00 Terrazzo Installation Manual

Terrazzo Colour Plates

TTMAC Fabrication Manual

As members of the TTMAC are continually striving to maintain and improve the standards of the industry, specifications are subject to revision at any time.

This guide supersedes the

Dimension Stone Guide Volume II

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Preface

The Terrazzo, Tile and Marble Association of Canada provides this Dimension Stone Guide to assist in clarifying and standardizing installation and specifications for dimension stone. This guide is revised periodically to provide architects and specification writers with current, accurate data on dimension stone installation. Quick-reference details and outlines in this manual cover most installation methods and conditions. Each installation recommendation requires a properly designed, constructed, and prepared substrate using materials and construction techniques that meet nationally recognized materials and construction standards.

Some installation methods and materials are not recognized and may not be suitable in some geographical areas because of local trade practices, climactic conditions, or construction methods. Every effort has been made to produce accurate guidelines, they should however, be used only with the independent approval of technically qualified persons.

Data presented in this document is strictly for information to the reader and does not necessarily represent the endorsement of the authors, the Terrazzo, Tile & Marble Association of Canada assumes no responsibility for the success or failure of any installation made in accordance with such data. The reader is expected to make judicious use of the data as part of their quest to further their knowledge. This guide is subject to revisions at any time with the approval of the Terrazzo, Tile & Marble Association of Canada.

Stone products less than 19 mm (3/4 inch) thick are addressed in the TTMAC Specification Guide 09 30 00 Tile Installation Manual.

The Terrazzo, Tile & Marble Association of Canada and the Construction Specifications of Canada Specification Committees acknowledges and is appreciative for the assistance freely given by many individuals for the compilation of this Dimension Stone Guide.

As with any building material and technique many variations including, but not limited to design, climate, topography, building and zoning codes, materials, labor costs and quality, markedly affect the safety, cost, utility, and appearance of the applications shown in this Manual. Accordingly, they are suggestive only and are not recommended or endorsed by the TTMAC.

Nothing in this manual should be used without independent approval by a qualified architect, professional engineer, contractor, or other technically qualified person who should also specify dimension stone and installation methods and systems, with specific location of expansion and control joints on drawings, and use of standards, such as those of the American National Standards Institute (ANSI) and American Society for Testing and Materials (ASTM) to develop specifications. It is the responsibility of the architect and specifier to include the necessary information in detail on drawings and specifications.

Accordingly, the TTMAC disclaims any guarantee or warranty, whether expressed or implied, for merchantability, fitness for a particular purpose, or any other purpose, or for safety, for anything described or illustrated herein, and assumes no responsibility for errors and omissions. No warranties, express or implied, including warranties arising from course of dealing or usage or trade, are made regarding the information, recommendations and descriptions contained herein. TTMAC is not responsible and will not be held liable in contract or tort (including negligence, strict liability, consumer protection statutes or otherwise) for any special, indirect or consequential damages, including injury or damage caused to persons or property by reason of installation, maintenance or failure of persons to heed caution or safety warnings.

References to ANSI or ASTM standards are merely suggestive and not mandatory and are NOT a TTMAC express or implied endorsement or warranty of the adequacy or completeness of those standards for safety or any other purpose.

For a reference only, some common (rounded nominal) industry metric conversions to the imperial equivalents may be found on page 137.

Brief History

The quarrying and use of natural stone products as a primary building material has been practiced for thousands of years. Evidence of this historical use can be seen in ancient ruins of early Egyptian and Roman architecture. The use of natural stone products even predates recorded history and was used to construct precious buildings in honour of kings and queens and ancient gods. In fact, some of the world's oldest buildings and most beautiful historic architecture utilizes manufactured, carved and finished natural stone products. Even today the demand continues for a large variety of natural stone products. Furthermore, many of the products used in ancient times are still available for consumer use.

Origins of Natural Stone

Various types of stones are excavated from geologic formations around the world. The primary geologic classification of rock used in construction stone include igneous stones, sedimentary stones and metamorphic stones.

Igneous Stones

The most common stone in this classification is granite, which is formed when magma (molten rock within the earth) slowly cools as it moves upwards towards the surface of the earth. The closer and faster the rock deposits move to the surface, the faster the rock cools, the faster the cooling process, the finer the grain structure. Granite is primarily comprised of Feldspar and Quartz. Other igneous rocks include Basalt and Porphyry.

Sedimentary Stones

This group includes travertine, limestone, sandstone, bluestone, brownstone, flagstone, quartzite, and limestone with seashells (often called shell stone) which were originally formed in seawater, or lakes from the sediment fossil remains of animals, plants, shells and other deposits of rocks and minerals. The compaction of these various deposit materials and the minerals cementing these deposits together, determine the hardness, density and porosity of the specific stone.

Metamorphic Stones

Marble and slate are both included in this group of natural stones. Metamorphic stones are produced from sedimentary or igneous rocks by the action of intense heat and pressure within the earth. Cleaved or foliated rocks are commonly called "Slates". A common characteristic of slate is its cleaved plane (layered) formation. The term "Foliated" means the folding or layering of metamorphic rock that occurs when pressure is applied in one direction and creates the layered cleavage texture of slate. Slate deposits are formed under less temperature and pressure; therefore, they are less dense than metamorphic stone such as marble. Other metamorphic stones include schist, gneiss, and quartzite.

Natural Stone Categories

Each type of stone is created differently and therefore has unique physical properties, making it suitable for specific applications. Scientists and Geologists have assigned hundreds of names to stones of slightly different mineral composition or formation process. For the purposes of specifying as a building material, the names given below should more than suffice.

All stones are composed of one or two basic groups: Silica or Calcium. These basic minerals are the primary considerations to the stones' applications.

> Silica based stones such as granites and slates are typically highly resistant to acids and corrosive atmospheric agents carried in rainwater and air, which makes these types of stones preferred for exterior use.
>
> Calcium Carbonate based stones such as Marble and Limestone are less resistant to acids and atmospheric agents. Marble and limestone, if used on exterior surfaces, will typically etch and wear at a faster rate than silica based stone. This is not to say that calcium carbonate stone could not be used on exterior applications, just that some surface weathering effects, over time, should be anticipated during the early design process. An appropriate stone testing procedure should be in place to assess and determine the suitability of a stone for a given application under specific climactic conditions.

Granite

An igneous granular speckled stone that is extremely durable, with some having a hardness approaching that of a diamond and is suited for interior and exterior application on floors, walls and countertops. Product is usually polished but is also available in honed, flamed, and water-jet finishes. Polished granite will tend to hold its sheen indefinitely, can be used in heavy traffic areas, and is less likely, when compared to marble or limestone, to be stained or damaged when exposed to food spills or normal household products.

Slate

A metamorphic stone formed of layered stone deposits. Product has a unique natural cleft surface and is available in a wide variety of natural earthy colours. Slate can be used for interior and exterior applications and in heavy traffic areas. Some slates are prone to surface layer delamination, particularly in wet environments.

Marble

A metamorphic stone that began as a limestone and through a metamorphic event recrystalized and became a marble. Product is normally supplied with a polish surfaced, but is also available in honed, sandblasted, or other finishes. Marbles are generally used on interiors for walls, counters, vanities and in moderate floor traffic areas. Most marbles are more prone to surface staining than granites or slates when exposed to food spills and other normal household products.

Limestone

A fine sedimentary stone that may contain fossil remains of plants, animals, and other mineral deposits. Limestone is provided in numerous finishes suitable for interior and exterior areas, floors, walls, and counters in residential and commercial projects depending on the physical properties of the stone.

Travertine

A sedimentary stone falling into the limestone family but traditionally often referred to as a marble. It is a very porous, often cavernous material, with a palette of various earth tones. The open grains can be filled during the fabrication process or left open in its natural state as desired by the designer. Travertine can be honed to a satin surface or finished to a semi-polished surface. Product can be used in various interior and exterior applications; however, caution must be taken when exposed to freeze/thaw climactic cycles.

Quartz Based Stone

Most types of quartz based stones are sedimentary with some having undergone metamorphic activity. The most common quartz based stones used in the building industry are sandstone and quartzite. Most often, these stones are supplied in a split face, natural cleft, or sawn finish. They are very abrasive and finishes such as honed or polished can be quite costly.

Serpentine

A metamorphic stone with igneous origin very similar and often grouped within the marble category but is different in composition. Most serpentine materials are dark or light green and are most often supplied in either a honed or polished finish.

Agglomerate Marble

A manufactured product created as a beautiful alternative to natural marble. Pieces of natural stones are bonded together with a polyester resin to create unique products. It is manufactured in a variety of colours including mixture variations not normally found in nature.

Engineered Stone

A manufactured product using natural stone and epoxy binders created with the technology that provides an extremely durable surface. This product is consistent in colour and visual movement with a wide range of colour.

Natural stone deposits suitable for use as building stones can be found on all continents and in every country. With the advancements in technology and improvements in transportation, new stones from new quarries and countries are being introduced to the marketplace each year. Quarrying methods and manufacturing techniques and processes differ depending on stone type and technology available.

Although there are different categories of natural stone products, each with their own advantages, the basic steps to the modern stone manufacturing process are:

1. Quarrying
2. Block Processing, Sawing and Sizing
3. Polishing, Honing, Slab Fabrication
4. Finished stone tile or cut to size slab
5. Packaging and shipping.

All these steps are critical and play an integral role in the success of the final project.

Quarrying

The extraction or excavation of stone from the earth is called the “Quarrying Process”. The two most common types of quarries are the “Open Pit” and the “Hillside Quarry”. Open pit quarries are very often found in plains or low lying areas that were former seabeds. Sedimentary stones are typically quarried in an open pit. Hillside Quarries are very often cut into the side of mountains and are very often Metamorphic stones. Igneous rocks, because of their formation from molten lava could be found in either open pit or hillside quarries. In either type of quarry, the stone is excavated in descending layers of the rock deposits, depending on the location of the natural faults or other physical characteristics of the deposit.

Natural stone is normally removed from the main rock deposit in large blocks. Block sizes vary depending on the type of stone, natural faults within the quarry or natural bed depth in the case of sedimentary stones. These large blocks of stone are extracted using various specialized saws, drills and hydraulic wedges to break the blocks from the main formation. Cleaved and foliated stones such as slate and quartzite are quarried quite differently. Slate and other cleaved stones are excavated in slab form of varying thickness depending on the cleavage plane. The slab is usually composed of several layers of dense stone separated by open cleaved planes naturally formed during the metamorphic process. Pry bars are used as wedges between the natural cleaved planes of the stone to split or separate the slab from the main stone formation. In some quarries blasting is used to extract slate. Once the slab has been excavated, it is removed from the quarry for final fabrication.

Other stones are extracted as boulders and sent to be cut into blocks, and then slabbed.

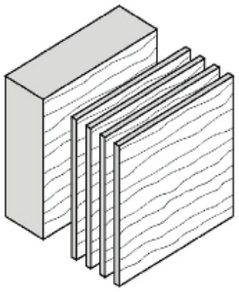
Block Processing, Sawing and Sizing

Block Processing is the term used to describe how the block is removed from the quarry once it has been cut free from the main deposit. After the block has been removed from the deposit, the next step is to square the block in preparation for transportation to the fabrication facility. Material that will not be used to create finished sellable product is sawed off and at least one side of the block is cut flat to expose the structural integrity and colour. The best quality blocks are selected for slab production, while smaller blocks and off cuts are often kept to produce finished tile sizes. The quality control of colour matching in the case of tile production is often very difficult because of the various sources of off cuts and blocks used in production.

Once the block has been excavated and arrived at the fabrication facility, the next step is to determine the “sawing orientation”. This is the process of determining the best direction to saw the block to obtain maximum possible yield and desired appearance. In sedimentary stones such as limestone, some marbles, and travertine, the natural veining within the stone will best determine the cut orientation. With these stones the cut direction has a significant effect on both appearance and technical properties. Most igneous stones, such as granite, cut orientation have no significant impact on the finished appearance or stone properties.

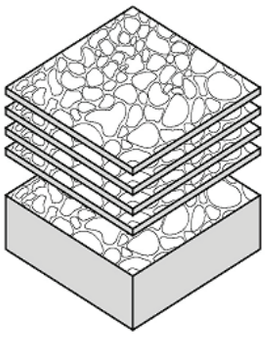
In sedimentary stones (example; limestone & travertine) the direction that the block is cut is referred to as either “Vein Cut” or “Fleuri Cut”.

“Vein Cut” or” Cross Cut” is referred to slabs that are cut perpendicular to bedding or layering of the deposit. These slabs tend to have a direction to them with veining visible on the face of the finished panel. The height of slabs is limited by the depth of the bench or layer. “Vein Cut” slabs generally exhibit lower flexural and compressive strength than “Fleuri Cut” and may be a factor in determining the stones suitability as a thin cladding or paving material.



VEIN CUT

“Fleuri Cut” is referred to slabs that are cut parallel to the bedding or layering. This is a cut through and between the veins, yielding a more mottled and cloud like appearance.



FLURRI CUT

Polishing, Honing, Slab Fabrication

Once the cut orientation is established the block must be cut into thinner slices (slabs) for further processing and finishing. These slices are then processed into either slabs or dimension stone tiles.

Slab Production and Processing

The blocks are cut into slabs with the use of gang saws and/or mono-blade saws. Mono-blade saws are usually used to square the irregular shaped blocks for evaluation as discussed earlier. They can also utilize a single reciprocating blade mounted into a large frame, and the block sits on a platform that rotates to the desired cut orientation, where a single pass through the block is made. The blade is moved a distance equal to the desired slab thickness plus an allowance for the blade, then a second pass is made. This is repeated until the blade reaches the end of the block.

Gang saws, utilize a series of reciprocating saw blades or diamond wires mounted onto a large, fixed frame base. The blades or wires are spaced to the desired slab thickness, and multiple slabs are produced in a single pass increasing production output. For this reason, these saws are more commonly used.

After the rough stone slabs have been produced, the next step is to apply a finish to one side. This process involves laying the slab flat, typically onto an automatic conveyer system. The slab is then fed through a finishing line consisting of a series of horizontal polishing wheels with progressively finer abrasive grits.

A single rotating cylinder with multiple polishing heads applies a downward pressure on the slab as it rotates and drives each polishing wheel. The pressure combined with the speed of the machine allows the abrasive to polish the slab to the desired finish. Other finishes can be applied to the slabs.

Dimension Stone Tile Production

Historically, the sawing process for tile production uses a large single diamond blade up to 3050 mm (10 ft) in diameter. Gang saws have now been developed and are being utilized to saw multiple strips simultaneously. Cuts are made along the entire length of the stone block with widths slightly wider than the desired width of the finished tile product. The multiple blade process increased production efficiency. The polishing process of stone tiles is very similar to that of slab finishing. The primary difference is that stone tiles are cut to the final dimension width strips prior to knowing the specific application. These stone strips sawn from the rough block are placed onto a conveyer system and fed through a series of grinding wheels and gauged to the desired thickness. Then the strips are fed through a series of abrasive polishing wheels to achieve the desired surface finish. The strips are then cut to the desired size, where the tile edges are rectified to ensure exact sizing. A beveled edge is also applied along the top of all sides to remove any sharp or rough edges. This creates a uniform finished product.

Fissure

A geological separation/fault line within a stone. These fault lines may be present in any type of natural stone. Depending on the severity of the fissure they may or may not have an adverse effect on the structural integrity of the stone (tiles, slabs, blocks or panels). The presence of fissures is due to seismic activity and may be interpreted as a natural geological characteristic of natural stone.

Surface Finishes

The most common surface finishes available are:

Polished Surface Finish

A polished surface will optimize the colour of the stone. Polishing a stone to a high gloss surface closes or reduces the size of the surface pores. Reducing the stones' porosity creates a resistance to soil and staining agents from penetrating the stones' surface. Generally, the higher the sheen or polish, the more resistant the stone will be to damaging conditions such as moisture, acidic solutions, and air pollutants. Unfortunately, the higher the sheen or polish, the lower the slip resistance, or coefficient of friction (COF) of the stone. Harder stones, such as granite will hold their polish longer under traffic than softer stones.

Honed Surface Finish

A honed finish is a semi-polished, smooth, matte surface finish with less sheen when compared to a polished finish. Because the abrasives used are somewhat coarser than those used to produce a high gloss, polished finish, the surface pores of the stone are more open and exposed than the surface of a polished finish. This increased porosity makes the stone less resistant to the effects of moisture, acids, and other staining agents. A honed surface finish is naturally more slip resistant than a high polished surface. This is an important consideration when using the stone in flooring applications, specifically in wet areas or exterior walkways.

Flamed (Thermal) Surface Finish

A flamed or thermal surface finish is achieved by passing a 2800 degree F torch flame over the surface of the stone. This process heats the various minerals and crystals and expands them until they explode or break from the body of the stone. The result of this thermal process is a coarse, irregular surface finish with an exposed pore structure. The flamed finish creates a look and texture which is desirable in certain applications. However, this open porosity also exposes the stone to weathering and other moisture-bearing contaminants. Not all stones can be flamed successfully. Most granite and certain individual materials from other categories can be flamed. The flaming process creates micro-fractures in the stone and can have a significant effect on the technical properties of the stone. It can also alter the colour of the stone, particularly with some limestones.

Natural Cleft Surface Finish

A natural cleft finish is a natural surface texture that is produced by splitting or separating stones which possess natural cleaved planes such as slate. The true colour of the stone is maintained during the splitting process and the natural cleft surface creates a unique look for a variety of applications. The amount of surface texture will vary with each stone and is primarily determined by the hardness or density of the stone. Less dense stones will cleave with greater irregularity than harder stones, which will cleave in flat, smoother planes.

Water Jet Finish

Although water jet technology has been used in various facets of stone processing, its use as a finishing tool is quite recent. High pressure water is used to penetrate the micro fissures of the stone loosening and removing the aggregate. The result is a textured finish similar to a flamed finish. Unlike flaming, water jet finishing does not wash out the colour of the stone, rather enhances it. The depth of finish can be controlled, unlike flaming, and does not jeopardize the structural integrity of the stone.

Note of Caution

Not all stones can achieve all the finishes described. Structure, texture, hardness, density, and mineral composition of a specific stone will determine the type of finishes which can be applied. Stone suppliers can provide limitations of the surfaces available for each stone.

LEADERSHIP IN ENERGY & ENVIRONMENT DESIGN

Environmental Statement: "Green has become measurable."

The construction industry has grown from just talking about "green" to certifying projects and products for providing a durable and sustainable environment for future generations. Today the trend is to focus on the efforts of such programs as LEED v4, the Living Building Challenge (1) and its Red List of unacceptable chemicals for materials used in construction, and the Delos WELL Building standard and its mission to improve human health and well-being through the built environment. In addition, green building codes are formalizing sustainable products as a primary consideration for new construction.

The role of EPDs (2) and HPDs (3). The trend in sustainability reporting it to move away from reporting recycled content and regional manufacturing to the use of product transparency information. Health Product Declarations (HPDs) and Environmental Product Declarations (EPDs) are based on a life-cycle assessment of the environmental impacts of a product or service- from the extraction and processing of raw materials, to the distribution, use and end of life of the product/service. EPDs are providing manufacturers with a uniform template to deliver this transparency information to their customers and end users.

Manufactures participated substantially in helping the Tile Council of North America to establish the first industry-wide EPDs for mortars and grouts used in the installation of porcelain, ceramic and natural stone tiles. The establishment of an industry-average EPD is important because the EPDs for mortars, grouts and tile can contribute 3 of the 20 products that are required for an EPD credit within the LEED v4 rating system.

1) Living Building Challenge (LBC) "Red List Free": A list within the LBC program that a specifier will often consult to ensure that certain chemicals are not in the products they are specifying (such as isocyanates and phthalate plasticizers.)

2) Health Product Declaration (HPD), Cradle 2 Cradle (C2C) Manufacturer's Inventory: Programs that focus on disclosure of a products ingredients. More specifically a Healthy Product Declaration (HPD) is an ingredient inventory that lists all the ingredients ("formula transparency") of a finished product and the associated health hazards with both intentional and residual ingredients.

3) Environmental Product Declaration (EPD): A concise environmental product performance report based on Life Cycle Analysis (LCA) to demonstrate the environmental impacts of a product from extraction of raw materials and processing to distribution use and end of life.

Technical Information

Stone, being a natural product extracted from various areas of the earth, will exhibit a wide diversity of different properties. Unlike manufactured products, where weight and structural properties can be determined and maintained through quality control programs, properties of stone have been pre-determined by Mother Nature.

A series of internally recognized tests have been established to determine whether a stone is suitable for a given application.

The American Society of Testing & Materials (ASTM) and the Marble Institute of America (MIA) have issued standards for the physical requirements of the natural stones most frequently used in construction. Most new stones being introduced to the market will be subjected to the standard ASTM tests with results submitted to the MIA for insertion into their book "Dimension Stones of the World".

These standards are primarily intended to uniformly evaluate stone and provide guidelines for architects, engineers, stone contractors, and other interested parties for the safe and economical use of natural stone in construction.

The following is a typical stone test chart included with each colour palette in the “Dimension Stones of the World” book.

Technical Information	Value	ASTM Test Method
Absorption by Weight, %	0.17	C97
Density, lbs./ft3	168.74	C97
Compressive Strength, psi	19,096.5	C170
Abrasion Resistance, hardness	39.18	C241
Flexural Strength, psi	1,354.3	C880

Technical values supplied by the Marble Institute of America (MIA) and the American Society for Testing and Materials (ASTM) are to be used as a guide in preliminary stone assessment. Actual stone properties may vary, and a project specific testing program may be required. One needs to understand a few basics related to the standard tests performed.

Absorption (ASTM C97)

This is a measure of the stone’s porosity. ASTM C97 is performed by weighing the stone sample dry and weighing it again after immersing it in water for 48 hours. The weight difference between the stone in a dry condition and after immersion is expressed as a percentage and is a measure of the amount of water that a stone will absorb. The lower the percentage, the less the moisture absorption rate of the stone. This can be a measure of the stones suitability for wet or freeze-thaw environments.

Density (ASTM C97)

The density of a stone is a measure of the stones weight and is expressed in lb/ft3 or kg/m3. The bulk specific gravity as established in ASTM C97 is the ratio of the density of stone to the density of water and is expressed as a whole number. The density of the stone is calculated by multiplying the bulk specific gravity by the density of water (62.4 lb/ft3 or 1000 kg/m3) (Example: Bulk Specific Gravity = 2.5 then the stone density is 2.5 x 62.4 lb/ft3 = 156 lb/ft3 or 2.5 x 1000 kg/m3 = 2500 kg/m3).

Compressive Strength (ASTM C170)

Measuring the compression strength of a stone determines the load a stone can resist before it will crush. The result of this test is expressed in pounds per square inch (psi). Compressive strength is useful in evaluating different stones for floor applications. Other properties like density, hardness and absorption must also be considered. This value is also used to determine minimum bearing area when stacking stones or using stones as lintels.

Modulus of Rupture (ASTM C99)

Modulus of rupture is a measure of the stones bending and shear strength. The test requires that the stone be tested both parallel and perpendicular to the rift or bed. The test requires that a minimum of five samples 100 mm x 200 mm x 57 mm (4 inch x 8 inch x 2-1/4 inch) thick with smooth faces be furnished for each condition, parallel and perpendicular, both wet and dry. A total of twenty samples are required. The specimens are supported at each end and loaded at the center until the stone fails.

Abrasion Resistance/Hardness (ASTM C241)

In addition to the MOH's scratch hardness test for ceramic tile, natural stone uses a similar testing and rating system. The test determines the natural stones' resistance to foot traffic abrasion when used as a flooring surface. The testing procedure involves measuring the amount of material removed from the surface of a stone sample through 225 revolutions of a grinding wheel. The calculation determines the loss of material from the grinding process, the higher the value, the greater the resistance to abrasion. ASTM Specifications list the minimum abrasion resistance for each type of stone.

Flexural Strength (ASTM C880)

Flexural strength is the measure of a stones ability to resist bending. Unlike the modulus of rupture test standardized at 57 mm (2-1/4 inch) thick, the flexural strength test uses the proposed thickness of the stone. The loading conditions are also different. The stone is supported at each end and loaded with 2 point loads located at the quarter points of the stone. This loading condition more truly measures the bending strength as opposed to shear strength. The results are expressed in pounds per square inch (psi). This test is essential when designing wall cladding and is used to determine the maximum span at a given thickness and can be used to determine kerf strength at anchor engagements although some designers feel Modulus of rupture should be used at anchor engagement.

ASTM Chart

The following chart lists the ASTM tests associated with Dimension Stone.

ASTM C615	Standard Specification for Granite Dimension Stone
ASTM C568	Standard Specification for Limestone Dimension Stone
ASTM C503	Standard Specification for Marble Dimension Stone
ASTM C616	Standard Specification for Quartz-Based Dimension Stone
ASTM C629	Standard Specification for Slate Dimension Stone
ASTM C1354	Standard Test Method for Strength of Individual Stone Anchorages in Dimension Stone
ASTM C1528	Standard Guide for Selection of Dimension Stone for Exterior Use
ASTM C120	Standard Test Method for Structural performance of Exterior Dimension Stone Cladding Systems by Uniform Static Air Pressure Difference
ASTM C1242	Standard Guide for Selection, Design, and Installation of Exterior Dimension Stone Anchors and Anchoring Systems
ASTM C170	Standard Test Method of Compressive Strength of Dimension Stone
ASTM C1352	Standard Test Method of Flexural Modulus of Elasticity of Dimension Stone
ASTM C880	Standard Test Method for Flexural Strength of Dimension Stone
ASTM C99	Standard Test Method for Modulus of Rupture of Dimension Stone

ANSI CHART FOR OTHER RELATED BUILDING MATERIALS

MATERIALS ANSI	INSTALLATION ANSI	MATERIALS ANSI	INSTALLATION ANSI
ANSI A118.1 Dry-set Portland Cement Mortar	ANSI A 108.5	ANSI A118.8 Epoxy Emulsion Mortar/Grout	ANSI A108.9
ANSI A118.3 Chemical Resistant Epoxy	ANSI A108.6	ANSI A118.9 Cementitious Backer Units	ANSI A108.11
ANSI A118.4 Latex Portland Cement Mortar	ANSI A108.5	ANSI A118.10 Load Bearing, Bonded Waterproof Membranes	ANSI A108.13
ANSI A118.5 Chemical Resistant Furan Mortar and Grout	ANSI A108.8	ANSI A118.11 Exterior Grade Plywood Latex Portland Cement Mortar	ANSI A108.12
ANSI A118.6 Standard Cement Grouts	ANSI A108.10	ANSI A136.1 Organic Adhesives	ANSI A108.4
ANSI A118.7 Polymer Modified Cement Grouts	ANSI A108.10	No ANSI Standard for Portland Cement Mortar Bed Materials	ANSI A108.1 A, B or C

General Requirements/Awareness

Stone products less than 19 mm (3/4 inch) thick are addressed in TTMAC Specification Guide 09 30 00 Tile Installation Manual.

The understanding of specific stone product characteristics and job conditions assist the consumer in determining a proper installation method. One should rely heavily on supplier expertise, along with the TTMAC Specification Guide 09 30 00 Tile Installation Manual for determining what products to recommend for use when installing natural stone in an interior application. For exterior applications, the TTMAC recommends using this manual as well as the expertise of someone with experience in the stone industry.

Acceptable Substrate for Flooring

Due to the weight associated with large unit natural stone, a properly prepared cement base, precast concrete or poured concrete surface is recommended. Other surface materials such as wood can be used if properly designed and are generally used in residential applications only. Properly cured concrete, cement backerboard unit (CBU), wire reinforced mortar beds, pre-cast concrete are all acceptable substrates. Refer to the latest TTMAC Specification Guide 09 30 00 Tile Installation Manual.

Crack isolation membranes provide protection against substrate cracks “telegraphing” through to the stone surface. They also can accommodate minor “in-plane” substrate movements. Stone installations are typically considerably more expensive than other materials and adding this extra level of protection is recommended.

Underlayments

Most natural stone flooring products are installed with grout joints not less than 1.5 mm (1/16 inch) to 3 mm (1/8 inch). Butt joints are not recommended. As a result, it is even more critical to ensure that the accepting surface substrate is smooth and flat. Self-leveling underlayments on floor areas or a slurry coat of acrylic modified mortar over CMU or CBU provide a quick and easy method to smoothing and leveling these areas.

Product Thickness Variation

Natural stone products are cut and rectified to specific thickness standards, which can vary significantly by product type and origin. Small to large variations can occur in the thickness and require special attention during the installation process. A medium-bed or non-shrinking thin-set is recommended for the installation of natural stone. These types of products allow for greater leveling capabilities due to their properties of thicker application without shrinkage, allowing the finished surface to remain flat after the thin-set has dried.

Mortar Bed

A mixture of Portland cement, sand and water installed to a thickness as required to provide an even substrate on which to apply natural stone. When a latex additive is to be used a minimum cure of 14 - 60 days is required before exposure to moisture. Verify cure time with the manufacturer. It may be accurately sloped where required and can be used to correct irregularities in sub-surface planes. On floors, mortar beds may be reinforced with 50 mm x 50 mm x 1.6 mm (2 inch x 2 inch x 1/16 inch) gauge galvanized or stainless square wire mesh.

Modified Dry-Set Cement Mortar (ANSI A118.4)

Modified dry-set cement mortars are designed for to improve adhesion, reduce water absorption, provide mild flexural capacities, greater bond strengths than non or unmodified dry set cement mortars. The additives allow mild latitude in working conditions, working time and temperatures.

These mortars will vary in composition based on their intended application and performance characteristics. Always consult with the manufacturer to determine suitability of the specified products for intended applications.

Epoxy Mortars (ANSI A118.3)

An epoxy resin normally filled with silica sand and combined with a hardener before application. Used as a bond coat where high bond strength and chemical resistance are required.

Modified Epoxy Emulsion Mortars (ANSI A118.8)

A three component mortar consisting of emulsified epoxy resins, a hardener and blend of Portland cement and sand. Modified epoxy emulsion mortars give high bond strengths and are used for similar applications as latex modified Portland cement mortars. They are not designed for chemical resistance.

Exterior Grade Plywood (EGP) Latex-Portland Cement Mortar (ANSI A118.11)

A modified Portland cement dry-set mortar to which a polymer has been incorporated in latex form or in a powder form for the bonding of stone to exterior grade plywood in interior dry or limited water exposure areas only. When added in latex form it is used as a replacement for water in accordance with the manufacturer's instructions.

Reinforcing Wire

Reinforcing wire in mortar beds should be galvanized especially when installing marble and other soft stones. Moisture contained within conventional mortar beds causes non-treated wire or lath to rust. The rust then can migrate through the stone to the surface, which can permanently stain and damage the natural colours.

Thin-set or Bonding Material Colour

Many natural stone products are translucent in nature and defused shades of darker materials can dramatically alter the colour shade of the installed stone. This is very prevalent with lighter coloured stones particularly some marbles and Quartz based stones. A white thin-set or bonding mortar should be used when installing translucent materials, allowing for little to no change in the natural colour. Epoxy coating the back of the stone can also help when installing translucent stones.

Grout Material

When installing polished material, it is recommended that the grout joint width not exceed 3 mm (1/8 inch) and that the grout material be of non-sanded type. Where grout joints exceed 3 mm (1/8 inch) in width sanded grout must be used. Consideration should be given to maintenance after installation when selecting the installation method and grout width.

100% Solids Epoxy Mortar

Some marbles and slates react to moisture during and after installation. Many of the green, red and some black stones will warp or curl when they come into contact with moisture. Use of these types of stones in wet areas is also not recommended. For installation of these products a 100% solid epoxy mortar setting system is recommended. 100% solids epoxy does not contain water and therefore does not cause warping or curling during the installation process. Epoxy can also be used to coat the back of the stone prior to installation, allowing a more conventional installation, while preventing water from entering the stone.

Wet Areas or Below Grade

Installing natural stone products in wet areas or below grade could cause discolouration due to natural water migration into the product. Care must be taken when selecting and designing stones at grade.

Product Staining During Grouting

Many natural stone products contain filler or are naturally very porous (Travertine is an example of this). Grouts contain coloured pigments added to either gray or white cement. These pigments can be absorbed and stain the surface of some stones when applied. A pre-grout sealer treatment can be used to reduce or eliminate the chances of staining by the grouting material. Consult the vendor's maintenance guidelines for proper product choice for pre-grout protection. An onsite test sample/mock-up is always recommended. Care must be taken to ensure the grout is compatible with the sealer and will bond to the stone.

Product Dusting

Natural stone is a quarried and fabricated product with water constantly present throughout the cutting and polishing process. Fine stone particles are mixed with the water, and these fine particles are often deposited onto the backside of the finished stone as the product dries. Additionally, some stones (limestone, sandstone, etc.) are naturally prone to microscopic surface particles dislodging or breaking free from the back of the material. In either case these fine particles form a light dusting that will prevent proper bonding of the stone. Prior to installation, the back of the stone should be wiped clean with a damp sponge and back buttered with setting material. This will remove the dusting and will ensure that bonding mortar (thin-set or epoxy) will properly adhere to the back of the stone.

Porous Materials

It is generally necessary to seal the stone prior to application of grout to prevent staining during the grouting process; take care to avoid sealing the edges which will prevent grout adhesion. Especially when using darker coloured grouts having heavy pigmentation.

Travertine

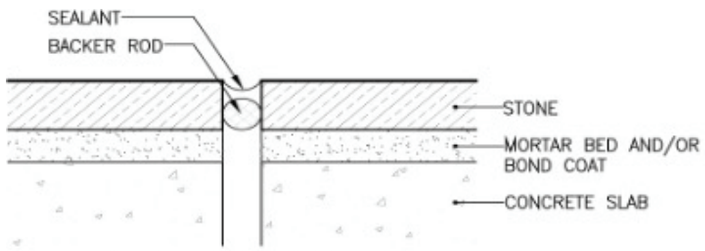
Travertine is a product that contains natural voids. These voids are often filled with matching colour compounds. Many of these compounds are susceptible to staining during the grouting process. It may be necessary to seal the stone prior to application of grout to prevent staining; take care to avoid sealing the edges which will prevent grout adhesion.

Test Small Area

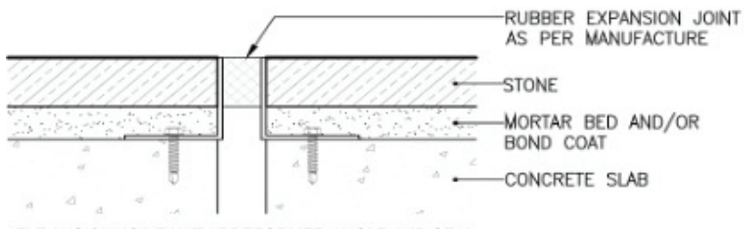
Always recommend that the customer test a small area prior to sealing the entire floor, to establish what the finished results will be. Never Use Acid. Never recommend use of any over the counter cleaners which are not specifically designed for the cleaning, care and maintenance of natural stone.

Movement Joints

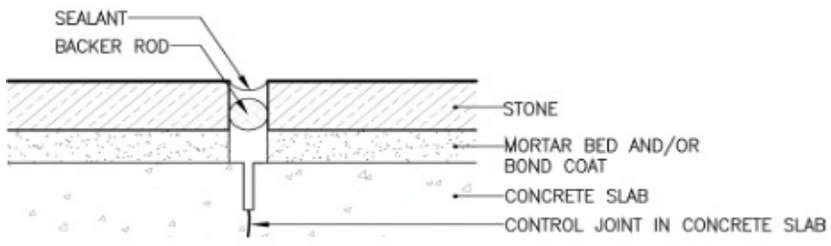
Expansion and control joints are required in both floor and wall installations. Expansion joints are located and designed by the building consultant to accommodate continuing movement in the structure throughout the life of the building. Expansion joints can also be required to control building drift, deflection caused by seismic loads, thermal expansion and/or contraction or other effects. These joints must extend through the substrate and the finish and often require the use of a rubber expansion joint incorporated into the stone installation. Expansion and control joints are more critical in adhered installations and not as critical in a mechanically fastened installation with caulked joints. Control joints are designed to account for movements within the stone field. The spacing and location of these joints should be specified on the drawings by the architect or designer, but are often left to the stone installer.



EXPANSION JOINT WITH SEALANT



EXPANSION JOINT WITH PREFORMED ANGLE AND SEAL



CONTROL JOINT

Lippage

Lippage is a term used to describe the condition where the edges of two adjacent slabs do not align; one being higher than the other, giving the finished surfaces an uneven appearance. In some conditions, when using thin-set methods, a minimum amount of lippage is unavoidable. As a general rule, the recommended maximum variation of the finished surface should be no more than 3 mm (1/8 inch) cumulative over a 3050 mm (10 ft) (3 m) lineal measurement, with no more than 1 mm (1/32 inch) variation between individual slabs. When using natural cleft stones lippage is unavoidable and larger joint size is generally recommended.

Deflection

It is recommended that the structure of a building intended to receive stone must be designed to have a total load deflection not greater that L/360. Allowance should be made for live load and impact as well as all dead load, including weight of stone and setting bed. It is recommended that live load deflection be design for L/720.

Traffic - Interior Flooring

One of the main factors when selecting a stone type and installation method for interior flooring is to consider the amount and the type of traffic it will be exposed to. Foot traffic varies from light (i.e. residential), to heavy (i.e. shopping malls). In some commercial applications flooring may also be exposed to many different forms of material handling equipment and lift traffic.

To determine the traffic capability of a given stone the Terrazzo, Tile and Marble Association Floor Testing machine is an approved test method.

Abrasive hardness is one of the key properties that must be assessed when selecting a stone type for flooring. Abrasive hardness is the abrasive resistance of stone subjected to foot traffic. To calculate this property, an ASTM C241 test is performed. High traffic areas would typically require an abrasive hardness of approximately twelve. If several different stone types are to be used in the same area, efforts should be made to select stones with similar Abrasive Hardness properties to ensure the even wearing of the floor. If Abrasive Hardness does vary, please refer to installation systems section.

Use ASTM C627 as an appropriate test method to determine traffic capabilities of any given stone.

Sizes

Size and thickness should be based on the stones properties as determined by ASTM testing, depending on the thickness of stone being used, the unsupported span, and the anticipated load. Standard thicknesses are 32 mm (1-1/4 inch), 38 mm (1-1/2 inch) and 50 mm (2 inch). Thicker material may be used as required.

Absorption

Absorption is defined as the percentage of water by weight, absorbed into a stone. This is easily measured with ASTM C97 and can be an initial indicator of the stone's suitability for use in exterior paving. That is not to say that stones with relatively higher absorption cannot be used, however this can be a significant factor in determining the long term performance of the stone and assessing the maintenance program required. Absorption is also an important factor to consider when selecting a stone for exterior cladding. With many stones, absorption is directly related to the stones ability to resist freeze thaw cycles, however, stone type and geology (Limestone, Granite, Marble) are just as important. As a result, testing should be performed to determine the suitability of stone for exterior use. Absorption can also have an impact on the stone's susceptibility to efflorescence and staining.

Warpage

Some types of stone have the tendency to break their true plane (i.e. warp). In the past, this has typically been the case with green and red marbles, and some slates. Most of the large adhesive manufacturers have products that are especially designed to cope with these materials. It should also be noted that this is more noticeable with larger panels. This is not only for the noted materials but with other materials as well. As a rule of thumb, the TTMAC recommends that panels fabricated from 19 mm (3/4 inch) material should be no larger than 915 mm x 915 mm (3 ft x 3 ft). In cases where larger panels are used, both a TTMAC member and adhesive member should be consulted.

Reinforced Materials

Many materials, particularly heavily veined materials and those with natural fissures, require reinforcing immediately after gang sawing and prior to finishing. Reinforcing is typically accomplished by applying a fiberglass meshing with matching resin to the back of the slabs. In many cases this is sufficient to ensure the material can be fabricated and installed without breakage. In extreme cases some materials require stainless steel rods to be epoxy embedded into slots cut into the back of the slab. Any material requiring extensive reinforcing (i.e. reinforcing rods) should be avoided in a flooring application.

A minimum of 90% of the stone surface must be in contact with the setting material to ensure the required bond. Reinforcing mesh and resin should be removed prior to setting if the reinforcing product is not properly bonded to the slab. Consult with the adhesive manufacturer and the stone manufacturer/ supplier to ensure that the setting materials being used are compatible with the reinforcing material.

Wet Areas

Stone cladding can be exposed to large amounts of moisture in several locations on the interior of a structure (showers, pools, laundry rooms, etc.). These areas must be noted and accounted for during the design stage of the building.

Thermal Expansion and Contraction

Thermal expansion and contraction must be considered when designing anchoring systems for exterior cladding, regardless of span or exposure. For thin veneer cladding, a mechanically anchored fastening system, individually supporting each panel, is preferable. Joint size, both vertical and horizontal, should not be less than 6 mm (1/4 inch) and should always be caulked. For thicker veneers, 65 mm (2-1/2 inch) and thicker a stacked mechanical system is typically used, and thermal movement must be accounted for with the use of vertical and horizontal expansion joints. These joints should be not less than 10 mm (3/8 inch) wide, located and spaced in accordance with the cladding design.

Hollow Sounds

Hollow sounds in some instances may be interpreted to mean the stone is not bonded properly. These sounds may be misinterpreted as resulting from an acoustical problem rather than a bonding issue. If the stone is set on a concrete slab over a large area as a garage, the “hollow” sound may be an echo. Also, air may be entrapped in either the setting bed or slab, causing one part of the floor to sound differently than another.

Separation or waterproofing membranes installed between a slab and the setting bed always reflect sound. The elevation of the subsurface may be irregular, causing one part of the floor to sound differently than another. The back surface of the stone unit may be irregular rather that flat, causing one part of the floor to sound differently than another. Lastly, there may be voids within the stone.

Industry standards require that a minimum of 90% of the dimension stone be in contact with the substrate. Adherence to this standard will result in minimal hollow sounds in a dimension stone installation. Hollow sounds do not affect the integrity of the installation unless there are visible signs of powdering and deterioration of the grout joints. Evidence of this joint deterioration may require the consideration of a pull test.

ENGINEERING REQUIREMENTS

Delegated Design: Delegated Design may be applicable to panel suspension components that require a response from the constructor or subcontractors for a project specific engineered design solution. The response can include contributions from trades, suppliers, and manufacturers to determine an appropriate design solution specific to the project, and can only happen when the subcontracts for the components of work are finalized.

Registered Professional of Record (RPR): The RPR is responsible for providing the constructor with explicit instructions when they need to acquire a single design solution based on loading conditions and performance attributes for specifically designated assemblies. Availability of multiple design to solve detailing conditions, requiring the RPR to illustrate a variety of acceptable detail options, could result in cost uncertainty to the owner and interpretation of the engineering design by the constructor when multiple pricing options are not broken out in the bid submission forms.

Project Architect's Responsibility: The project architect is typically setup as the co-ordinating registered professional, and is responsible for co-ordination in their construction documentation, identifying where delegated design components are described within different disciplines' construction documentation (including out of house subconsultants).

Project Engineer's Responsibility: The Engineer of Record maintains responsibility for any design that requires engineered solutions. Pre-engineered supports using span tables or load chards do not form a part of delegated design and are handled like other shop drawing or product data submittals.

Manufacturer's Responsibility: Delegation responsibilities of the manufacturer are typically limited to aiding the project architect and project structural engineer. Most delegated design/engineered design solutions are completed by the subcontractor.

Subcontractor's Responsibility: Engages with an Supporting Registered Professional (SPR) that has explicit and direct experience in the design and engineering analysis of the delegated design component or assembly.

Constructor's Responsibility: Co-ordinates appropriate and agreed upon review and rework of shop drawings and other submittals with RPR and SRP for timelines necessary for shop drawing review and potential incorporation of review comments and markups.

Design Responsibility and Liability: There is not transfer of project liability to the supporting professional engineer, the constructor, the subcontractors (trades), suppliers and manufacturers. Professional practice legislation typically states that design responsibility associated with the design solution remains with the supporting professional engineer, but the engineer of record is responsible for confirming that the design solution meets the design intent for the project thereby maintaining responsibility for project liability.

Design Assist: Design assist is a better solution than delegated design, and is more achievable on projects where a construction management or design build contract delivery is in place.

These forms of contract allow for more cooperation and early procurement than traditional stipulated price contracts. Design assist can work with stipulated price contracts where the owner is able to engage with early procurement of engineered building components and assign these elements to the constructor using a form of novation to incorporate the design assist contract into the project contract.

For additional discussion on Delegated Design, refer to:

- https://www.constructioncanada.net/assignment-of-design-to-constructors-a-discussion-and-direction/

- https://www.constructioncanada.net/assignment-of-design-to-constructors-documentation-and-drawings/

- https://www.constructioncanada.net/assignment-of-design-to-constructors-a-road-map-towards-effective-delegated-design/

EXTERIOR STONE - VERTICAL APPLICATIONS

Stone selection, installation method and detailing are most critical when dealing with exterior stone in vertical installations. The exterior environment, including but not limited to such things as moisture, acid rain, freeze thaw conditions, wind loads, and thermal expansion and contraction are all factors that affect the performance of the stone cladding system. Engaging qualified consultants, professional engineers experienced in the design of stone along with a qualified TTMAC contractor will ensure success.

In choosing a stone for exterior cladding, several factors must be considered. Although colour, texture, veining and/or grain size are always critical aspects to architects and designers, there are other aspects that must override these, when selecting a suitable stone. Some of the more obvious aspects are:

• Strength – Is the stone strong enough to withstand all the design loads at the thickness and size specified?

• Block size – Is the stone specified available at the size detailed on the drawings?

• Finish – Is the finish suitable for the proposed application?

• Exposure conditions – Is the stone exposed to high levels of pollution? Will the stone undergo several freeze thaw cycles? Is the stone exposed to high levels of sodium (coastal exposures)?

Most stones quarried and sold today, have readily available ASTM test data including density, compressive strength, flexural strength, absorption, and abrasive resistance. This test data is valuable for providing information for the initial evaluation and selection of a stone for a particular application in a given location. Current test data must be performed in order to determine the actual strength of the stone being quarried and used for the project.

The thickness of stone typically used for exterior cladding ranges between 32 mm (1-1/4 inch) and 50 mm (2 inch) with 32 mm (1-1/4 inch) being the recommended minimum. Material type, panel size, anchoring system and loading conditions will determine the minimum thickness required. If thickness has been predetermined and the proposed panel sizes exceed the allowable spans of the selected material, then additional joints or reinforcement of the panel may be required to reduce the stresses on the material or another material with greater strength selected.

Local building codes may also govern the maximum panel size and minimum thickness.

GENERAL INFORMATION

Sampling and Mock-Ups

The stone subcontractor (SB) shall submit samples of all the specified dimension stones to the architect for approval. The sample sizes should be specified by the architect at the time of tender. The number and size of samples should clearly show the colour and shading range that will be acceptable, as well as identify extreme veining and/or inclusions. Samples must be unconditionally approved or rejected in their entirety. In some cases, architects and contractors will view and select the actual slabs to be used for the project.

In larger projects the architect may specify a mock-up. The function of the mock-up is to provide the architect and owner with a view of the finished stone product and its relation to the adjacent building components. The mockup very often involves several trades working together to provide a mockup that clearly illustrates the interface with the building materials. A typical stone mock-up consists of stone panels clearly illustrating the range and fabrication tolerances. The panels are to be installed using the proposed engineered and approved anchors, along with any sealant and/or grouts. Mock-ups can form part of the completed work.

Shop Drawings

Properly detailed shop drawings are an essential component of the exterior cladding process and can play a critical role in the success or failure of the project. Shop drawings must clearly convey all relevant information to the architect, contractor and installer. Relevant information is to include the necessary plans, elevations, sections and details to clearly dimension and detail all the stone and its interface with adjacent building materials. They must also include all critical grade elevations such as sill heights, top of windows, top of copings, etc. The drawings must include professional engineer stamped anchor details for the fastening of the stone. The architect and general contractor are to ensure that all information on the shop drawings has been interpreted properly and approve the dimension information on the drawings. With the lead times required to fabricate stone, providing dimension approval at an early stage will allow for expeditious material procurement and ordering and in turn ensure material is delivered on schedule. Project specifications should clearly indicate the shop drawing requirements and architects should accept nothing less.

Safety Factors

As with any engineered material, safety factors must be included in the design that consider, material variations, loading conditions, imperfect workmanship. Stone, being a natural product, quarried from the earth requires a safety factor that will ensure that the allowable stresses in the stone are never exceeded. There has been much discussion on what an appropriate safety should be. Some published material and design codes have related safety factors to the stone type; granite being designed to a safety factor of 3-4, marble to 4-6, and limestone 6-10. What is becoming more customary in the industry is relating the safety to the variability in the stone testing results. A stone demonstrating very constant testing results (a low coefficient of variation) is designed with a lower safety factor and one with a high coefficient of variation is designed with a higher safety of factor.

Safety

Material logistics possess its own challenges. The safe movement and storage of material must be considered.

DESIGN COMPONENTS

Fastening Systems

The selection of an anchoring system is dependent on the substrate supporting the stone, the type and thickness of stone, and the forces acting on it. Anchors can be plates, angles, wire ties, continuous extrusions, dowels, other proprietary fasteners, or a combination of these components. From an installation perspective, it is preferred to have four anchors per panel with two located at the bottom and two on top. All veneers over 3049 mm (10 ft) from grade must be engineered and stamped. In several cases, anchors are misinterpreted by architects and designers as masonry ties. In the transition to thinner veneers, the traditional masonry tie and stacked stone has continued to be incorrectly used in many thin cladding projects. Anchors must be capable of independently supporting all the loads imposed by each stone. Thin stone veneers (32 mm (1-1/4 inch) – 50 mm (2 inch)) should not be stacked. The failure or breakage of a stone should not affect any of the adjacent stones. It is highly recommended that all anchoring components be manufactured from grade 304 stainless steel. Hot dipped galvanizing and the use of dissimilar metals can result in corrosion problems. If using a combination of hot dipped galvanized and stainless steel, the dissimilar metals must be separated with a di-electric separator. The cost to upgrade to an all-stainless anchoring system is usually negligible when compared to the total cost of the cladding project. All-stainless offers peace of mind that the anchors will perform as detailed for the life of the building.

Refer to Engineering Requirements discussion on page 25.

Physical Properties - Stone

The strength of the stone and its properties are acquired through ASTM testing. Most stones quarried and sold today, have readily available ASTM test data. The most common test data provided are density, compressive strength, flexural strength, absorption, and abrasive resistance. Compliance with these physical requirements specified by the ASTM material standards verifies only that the stone under consideration has at least the same quality as other stones of the same type. This test data is useful for the initial evaluation and selection of a stone.

Several factors must be considered in the stone selection process including environmental exposure, size of proposed panel, thickness of proposed panel, substrate material, anchoring system, etc. Any one of these factors could result in a stone being unsuitable for the intended use. Stones perfectly suitable in one environment may be unsuitable in another.

Current test data must be performed in order to determine the actual strength of the stone being quarried and used for the project. Stone is absorptive and wetness dependant with potentially large variations in material properties. Stone properties vary greatly depending on the orientation of the rift. The determination of the flexural tensile strength of the stone (ASTM C880) and the pullout/push-through resistance of the connector where it engages the stone or is bedded in mortar (ASTM C1354) are critical for the engineering of stone veneer systems. The maximum span, minimum thickness and maximum area of stone panel determined by engineering analysis should be confirmed by full scale panel testing in accordance with ASTM C1201. For some larger projects, full-scale mock-up testing before finalizing the design and before construction commences to confirm structural and environmental separation performance should be considered. Reputation of stone by usage is no less important than laboratory tests.

Refer to chart on page 16 for listing of ASTM tests related to dimension stone.

Substrate

The types of substrates used by the building designer can, in many cases, determine the success or failure of a cladding project. Commonly used substrates in order of preference are:

• Cast-in-Place Concrete – the preferred substrate for exterior and interior cladding. Anchors can be placed were required. Anchor capacities are highest when installed into concrete.

• Concrete Masonry Units (CMU) – When used for interior cladding where panels are stacked is a suitable substrate. If used for exterior cladding, the CMU must be solid filled with masonry grout to ensure anchors can achieve the required capacity. If masonry is not properly filled, positive anchorage is very difficult to achieve and may require the use of adhesive anchors. These anchors are more costly and require time to set up, particularly when temperatures are low.

• Steel subframes – When designed by the stone installer's engineer, can be a effective and economical substrate. However, if the frames are not designed to accommodate the stone designer's anchors, they can be ineffective and very often require either additional steel, or the stone designer to design an expensive anchoring system to suit the steel provided.

• Structural Metal Stud - When used for interior cladding where panels are stacked, is an acceptable substrate. When used for exterior cladding, it is the least preferred and is not recommended. The capacity of anchors into metal studs is limited. Placement of the studs is critical and the service life of the anchorage into metal studs is generally much lower than the stone and can be dramatically reduced by corrosion at the anchors, however, cladding the metal studs with plywood can add to the stiffness of the wall assembly.

Physical Properties - Stone

The strength of the stone and its properties are acquired through ASTM testing. Most stones quarried and sold today, have readily available ASTM test data. The most common test data provided are density, compressive strength, flexural strength, absorption, and abrasive resistance. Compliance with these physical requirements specified by the ASTM material standards verifies only that the stone under consideration has at least the same quality as other stones of the same type. This test data is useful for the initial evaluation and selection of a stone.

Several factors must be considered in the stone selection process including environmental exposure, size of proposed panel, thickness of proposed panel, substrate material, anchoring system, etc. Any one of these factors could result in a stone being unsuitable for the intended use. Stones perfectly suitable in one environment may be unsuitable in another.

Current test data must be performed in order to determine the actual strength of the stone being quarried and used for the project. Stone is absorptive and wetness dependant with potentially large variations in material properties. Stone properties vary greatly depending on the orientation of the rift. The determination of the flexural tensile strength of the stone (ASTM C880) and the pullout/push-through resistance of the connector where it engages the stone or is bedded in mortar (ASTM C1354) are critical for the engineering of stone veneer systems. The maximum span, minimum thickness and maximum area of stone panel determined by engineering analysis should be confirmed by full scale panel testing in accordance with ASTM C1201. For some larger projects, full-scale mock-up testing before finalizing the design and before construction commences to confirm structural and environmental separation performance should be considered. Reputation of stone by usage is no less important than laboratory tests.

Refer to chart on page 16 for listing of ASTM tests related to dimension stone.

Substrate

The types of substrates used by the building designer can, in many cases, determine the success or failure of a cladding project. Commonly used substrates in order of preference are:

• Cast-in-Place Concrete – the preferred substrate for exterior and interior cladding. Anchors can be placed were required. Anchor capacities are highest when installed into concrete.

• Concrete Masonry Units (CMU) – When used for interior cladding where panels are stacked is a suitable substrate. If used for exterior cladding, the CMU must be solid filled with masonry grout to ensure anchors can achieve the required capacity. If masonry is not properly filled, positive anchorage is very difficult to achieve and may require the use of adhesive anchors. These anchors are more costly and require time to set up, particularly when temperatures are low.

• Steel subframes – When designed by the stone installer's engineer, can be a effective and economical substrate. However, if the frames are not designed to accommodate the stone designer's anchors, they can be ineffective and very often require either additional steel, or the stone designer to design an expensive anchoring system to suit the steel provided.

• Structural Metal Stud - When used for interior cladding where panels are stacked, is an acceptable substrate. When used for exterior cladding, it is the least preferred and is not recommended. The capacity of anchors into metal studs is limited. Placement of the studs is critical and the service life of the anchorage into metal studs is generally much lower than the stone and can be dramatically reduced by corrosion at the anchors, however, cladding the metal studs with plywood can add to the stiffness of the wall assembly.

Insulation and Vapour Barriers

Stone cladding is the outermost component of the building envelope. It is typically backed by an air space, rigid insulation, and an air and vapour barrier membrane. Continuity in the insulation and vapour barrier are critical to the performance of the wall assembly. Anchors are typically required to penetrate through these components. Care must be taken to design adequate clearance from the back of the stone to the substrate to accommodate insulation, vapour barrier, anchoring system, air cavity and construction tolerances. When installing the anchors, a procedure must be outlined to ensure that the anchors do not have a negative impact on the performance of the building envelope.

Vents/Drains

Most exterior cladding installations form part of a “rainscreen” wall. This wall includes an air cavity immediately behind the stone. One of the functions of the cavity is to manage moisture. This is accomplished by providing vents to allow air to enter the cavity and dry any moisture contained in it and by providing drains to allow any water entering the cavity to escape.

Expansion /Control Joints

Several forces will be acting on a stone veneer once installed. These may come in the form of building deflections, thermal expansion and contraction.

Expansion joints are determined by the architect and prime structural engineer and are designed to allow for structural movement within the building. These are specified and located in the drawings. The cladding anchor design must allow for these movements without having a detrimental effect on the performance of the installation.

Control joints are typically determined by the stone engineer and are mainly designed to allow for movement within the cladding itself. When joints are caulked, the need for control joints is usually eliminated.

Jointing

Joints typically range from 6 mm (1/4 inch) to 12 mm (1/2 inch) on vertical surfaces. Where vertical cladding meets horizontal paving an increased joint size of 12 mm (1/2 inch) to 20 mm (3/4 inch) is recommended to accommodate movement resulting from frost or water. When using sealant in the joints, testing should be performed to ensure the sealant adheres to the stone, provides adequate elasticity, and does not stain the stone. Consult with manufacturer for cleaning procedures of the caulking and forward the information to the contractor. Ensure that any cleaning agents used, will not stain or damage the finish of the stone.

PRECAUTIONS

Geographic Variables

Local building codes, architects and contractors are the best source of information when dealing with local geographic variables. Although these guidelines attempt to address all possible factors of exterior stone cladding, the guidance of local experts should be consulted.

Thermal Expansion and Contraction

The heating of the stone due to the suns rays can be dramatic, particularly with dark stones on southern exposures. Control joints can assist in coping with this variable.

Graffiti

The exposure to graffiti is a growing problem that most metropolitan cities face. Determine if anti-graffiti products will be required. Test samples of the stone prior to installation to review their reaction to these products. Most anti-graffiti products consist of a sealer and a stripper. Test both components.

Snow Removal

Snow removal efforts, both mechanical and manual, can damage exterior stone cladding. Consideration should be given to filling the cavity behind the stone to a 305 mm (12 inch) level above finished horizontal surface. Increasing the thickness of the stones will also help to reduce damage from snow removal.

Hysteresis

The formation of the stone and its various mineral composites give stone its distinct character. One characteristic, which must be considered when reviewing installation requirements and selecting stone, is the stone's ability to return to its original volume and plane when exposed to moisture and changes in temperature. Some stones, in particular, true marbles, experience small changes in volume when exposed to moisture and/or extreme temperature variations. This phenomenon is referred to as "Hysteresis". The exposed face of the stone will cool or heat faster than the sheltered surface. This differential expansion causes the exterior of the panel to bow outward. As the stone continues through these cycles, the stone continues to bow and eventually begins to affect the anchorage and the adjacent panels or other cladding components. As the panel face continues to bow, the surface develops micro fissures and becomes more susceptible to freeze thaw action and the effects of moisture penetration. The use of these should be avoided for certain applications. In some cases, increasing the panel thickness will reduce the effects of Hysteresis.

Efflorescence

Efflorescence is the salt residue, sometimes found on the surface of a stone caused from the migration of moisture either through the stone or deposited onto the surface. Efflorescence is very often noticed at grade. As moisture moves through the stone, most often through capillary action of a stone in contact with the ground or soil, deposits of salt are left behind on the surface of the stone as it begins to dry, and the moisture evaporates. The salt saturated moisture may enter the stone in various locations. Proper drainage and setting techniques must be employed to ensure the rapid movement of salt saturated moisture away from the stone panels. Prolonged exposure to high levels of salt saturated moisture may lead to spalling. Preventing the stone from contact with the grade or soil and providing positive drainage are the most effective ways to prevent efflorescence. Sealing the stone at the base may also assist in preventing efflorescence.

TOLERANCES

Stone Fabrication:

Panel thickness	+3 mm (1/8 inch) / - 0
Square	+1 mm (1/32 inch) / - 1 mm (1/32 inch)
Length	+1 mm (1/32 inch) / - 1 mm (1/32 inch)
Height	+ 1 mm (1/32 inch) / - 1 mm (1/32 inch)
Flatness	+ 1 mm (1/32 inch) / - 1 mm (1/32 inch)

Installation:

Variation of finished surfaces will not vary more then 1mm (1/32 inch) between panels and no greater then 3049 mm (10 feet) over 3500 mm (11 feet 6 inch).

Substrate:

Maximum deflection of L/480 for adhered veneers

Maximum deflection of L/360 for mechanically fastened cladding

Plum +12 mm (1/2 inch) –12 mm (1/2 inch) over 3.5 mm (1/8 inch)

Flat +12 mm (1/2 inch) –12 mm (1/2 inch) over 3.5 mm (1/8 inch)

Installation Systems

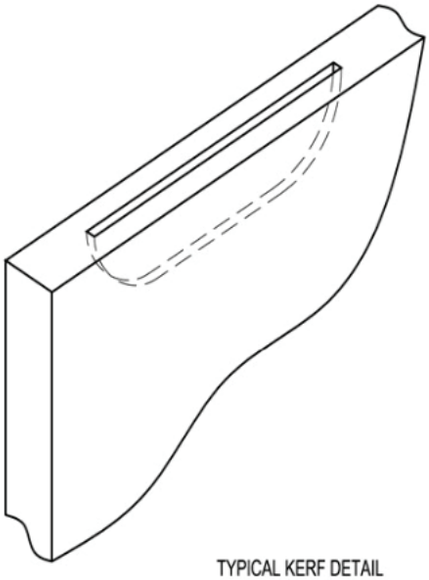
Stone cladding for exterior applications typically range from 32 mm (1-1/4 inch) to 50 mm (2 inch) in thickness. Properties of the stone, engineering, anchoring design and local building codes will provide the guidelines to determine the appropriate panel size and thickness of stone. The following are recognized and approved systems of installation.

Mechanically Anchored - Standard

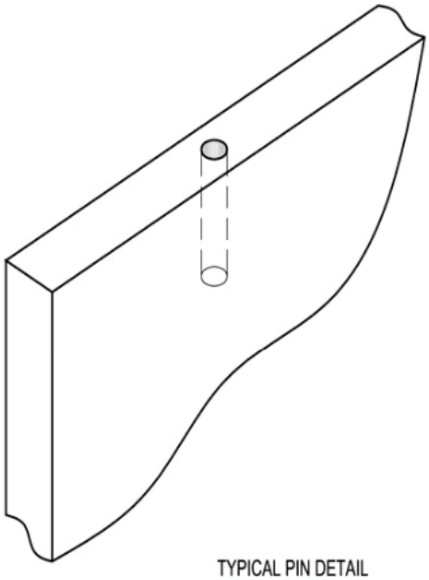
Introduction

A mechanical anchor can be classified as a single or multi component system designed to transfer the forces acting on the stone panel to the substrate. Anchors must independently support the load of each stone panel and not transfer the weight of the upper panel onto the panel below it. This method is often referred to as hand set. The preference for both engineers and installers is to have two anchors bottom and two top located at quarter points. Typically, each anchor is designed to resist both vertical and lateral loads and is located in the panel joints, so it engages two panels. The anchor supports and laterally restrains the upper panel and provides lateral support for the lower panel. The anchor engages the stone with either a pin or “split tail” plate. With a pin, the stone requires a hole approximately 2 mm (1/16 inch) greater in diameter than the pin be drilled into the stone’s edge. With the split tail plate, the stone requires a “kerf” which is a saw cut in the edge of the stone approximately 2 mm (1/16 inch) wider than the thickness of the plate. These anchor holes or kerfs are filled with non-staining sealant. The sealant serves a few functions; it prevents moisture build up, provides a cushion between the stone and the anchor and stabilizes the connection preventing any movement within the anchor.

There are two basic anchor types:



TYPICAL KERF DETAIL



TYPICAL PIN DETAIL

Application

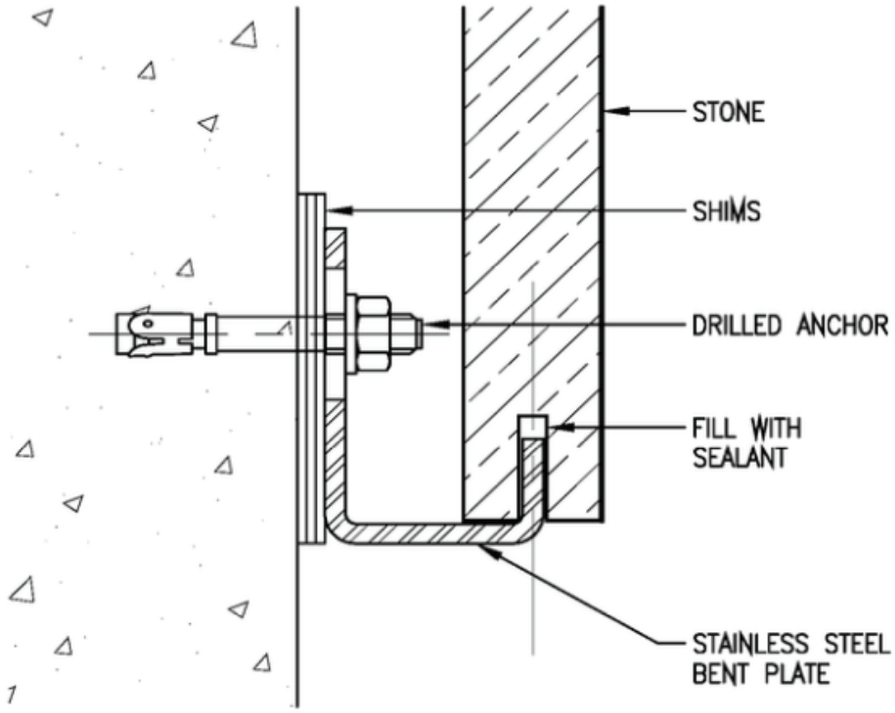
This system is the most commonly used anchoring system for thin stone installation. The majority of building codes require this application to be used on walls higher than 3049 mm (10 feet) (check local building codes) and on veneers which typically range in thickness from 32 mm (1-1/4 inch) to 50 mm (2 inch). Cladding materials 65 mm (2-1/2 inch) or thicker usually stacked and either mechanically anchored or laid in mortar similar to brick.

Substrate

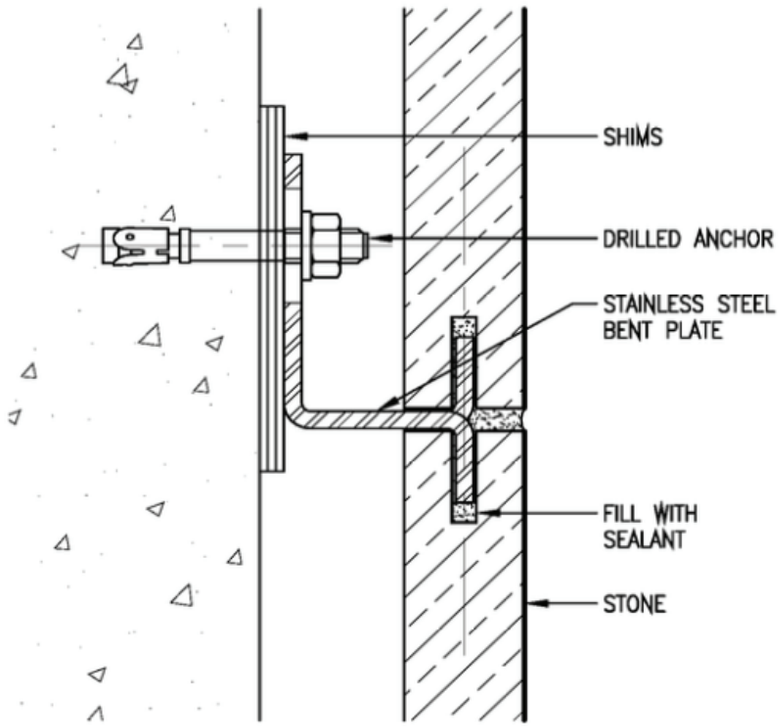
Acceptable substrates include structural concrete, solid masonry or structural steel. Metal stud substrate used in load bearing anchoring applications is not recommended. Difficulties arise in coordinating stud locations to align with anchor requirements. Anchoring through the exterior sheathing and achieving adequate support is often difficult and many building codes do not permit the use of self drilling screws to support stone cladding requiring the use of bolts. Bolting through metal studs with exterior sheathing becomes a very labour intensive endeavour and requires access to the back of the wall. Care must be taken during the design phase to ensure that vapour barriers and insulation requirements of the building envelope are not compromised. Thick vapour barriers may restrict the angle from properly bearing against the substrate. Some vapour barriers act as lubricants allowing the angles with vertical slots to slide. In these cases, a locking washer or devise used to lock the angle into place preventing slip is recommended. Horizontal or angled slots may be used in these cases.

“One Piece Anchor”

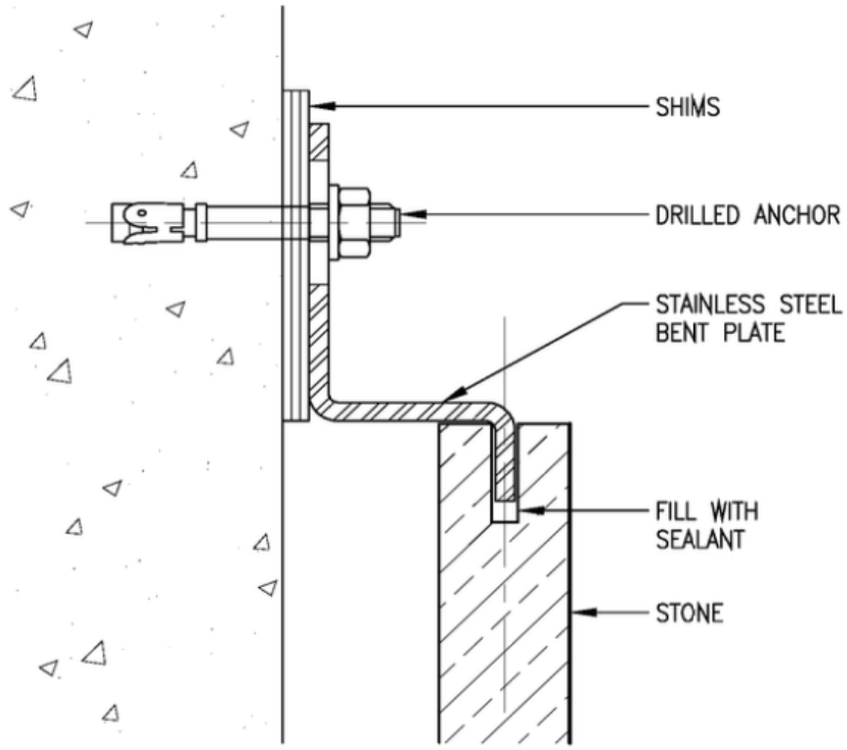
Referred to as a one piece anchor, it does consist of a stainless steel plate and a fastener. The fastener can be a wedge or sleeve anchor if connecting to concrete or block respectively, or a bolt or self drilling screw if connecting to steel sub-frames or metal studs. A one piece anchor is used when the cavity size is less than 65 mm (2-1/2 inch). This anchor offers little adjustment in and out and requires the substrate to be very accurate. Stone installers are often forced to site verify the accuracy of the substrate before ordering anchors.



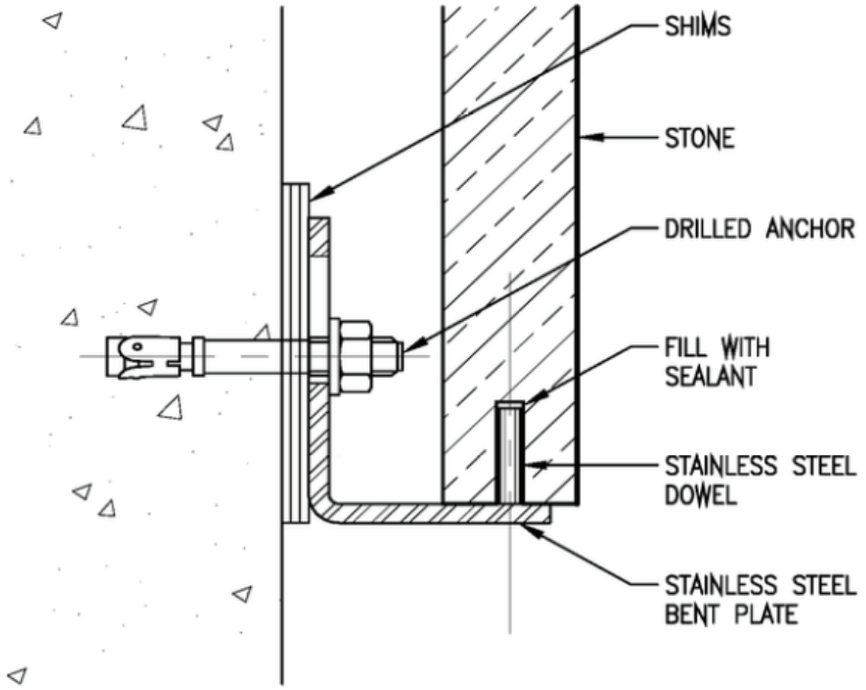
ONE PIECE KERF BASE CONNECTION



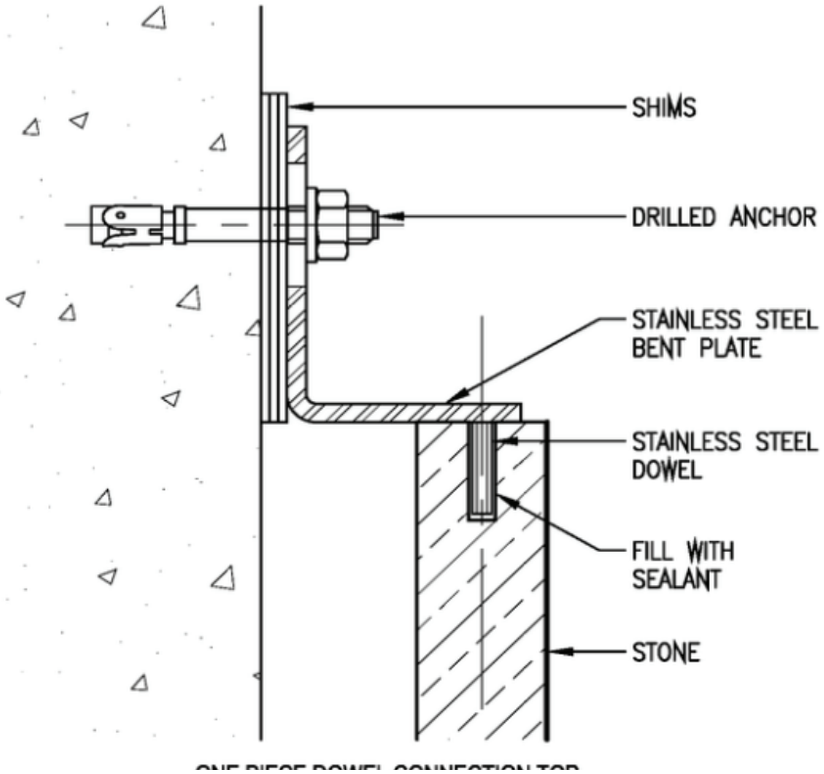
ONE PIECE KERF MID HEIGHT

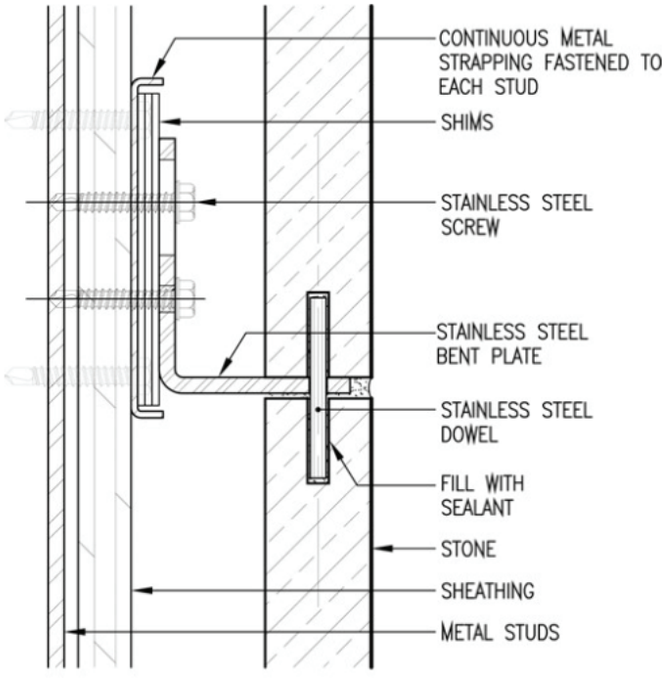


ONE PIECE KERF BOTTOM



ONE PIECE DOWEL BASE CONNECTION

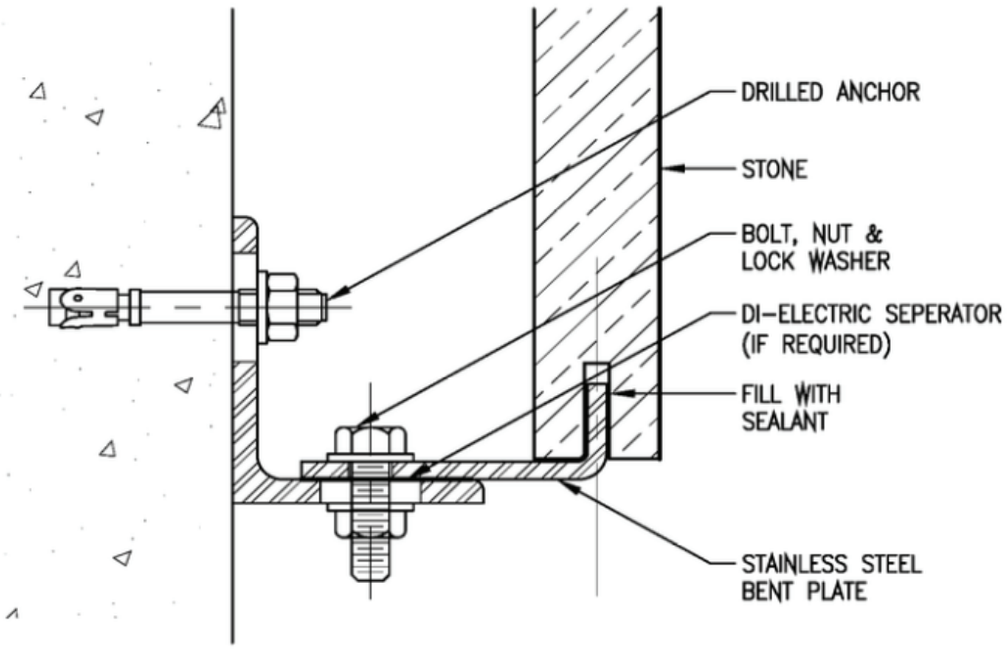




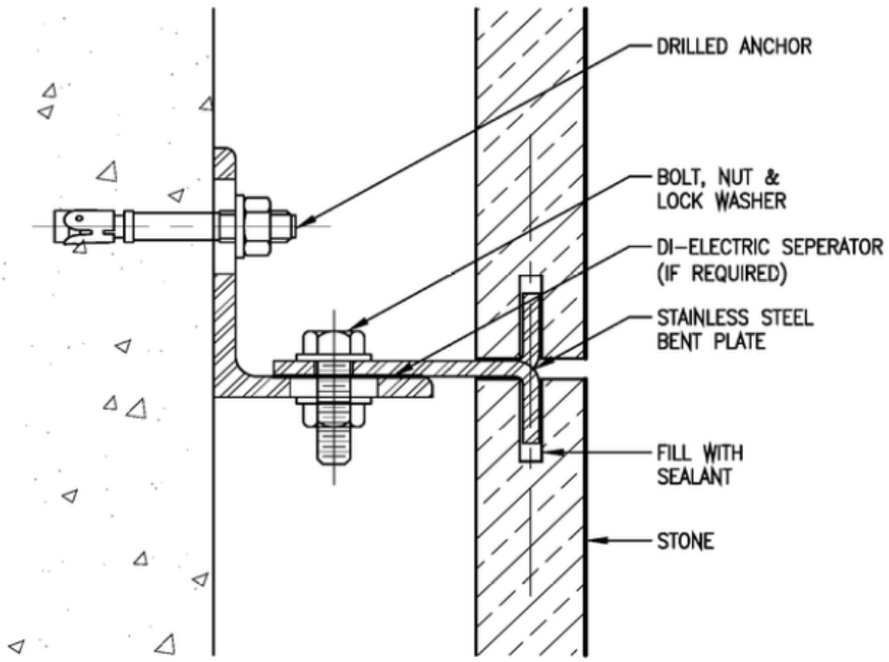
ONE PIECE ANCHOR TO METAL STUD CONNECTION MID-HEIGHT

“Two Piece Anchor”

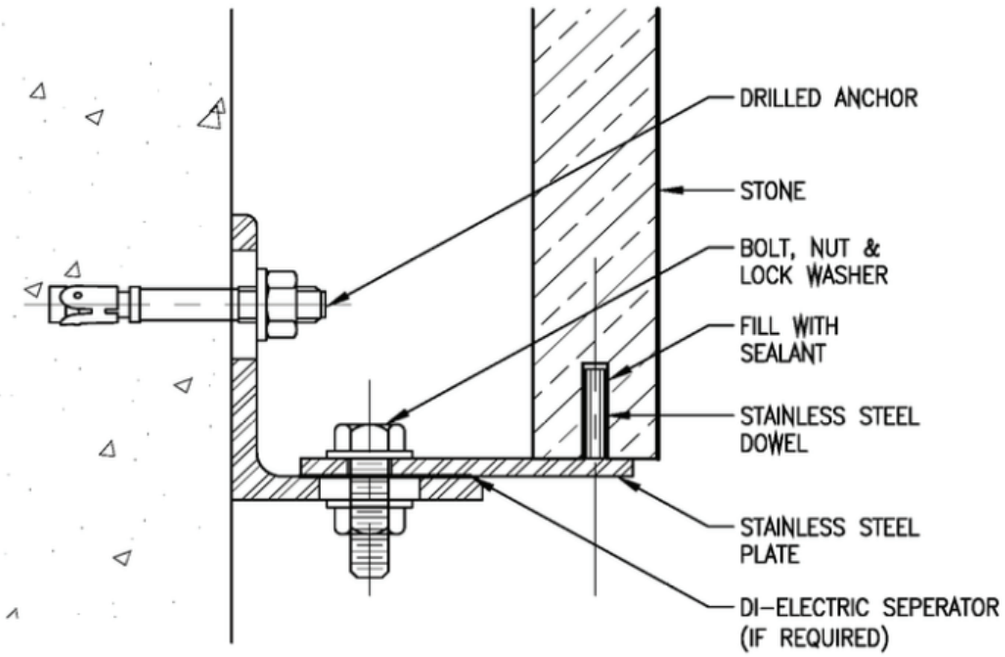
This anchor consists of an angle and a plate connected with a bolt and fastened to the substrate like the one piece anchor. This anchor can only be used with cavity spaces greater than 65 mm and offers much greater adjustment. Both the angle and plate can be fabricated with slots at the bolt and fastener locations offering adjustment vertically and horizontally.



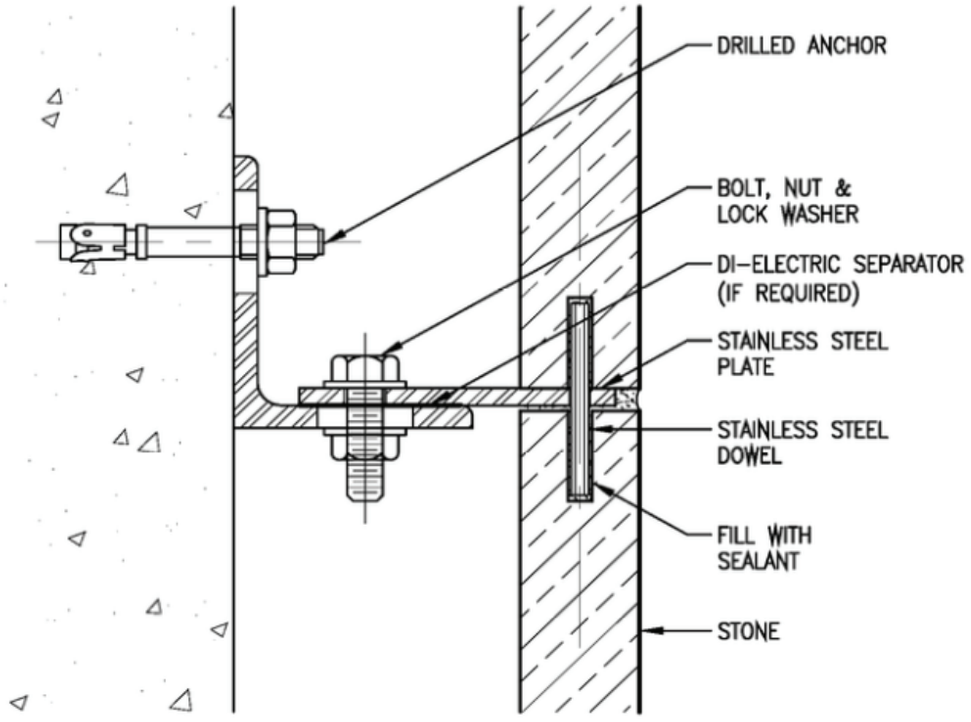
TWO PIECE KERF BASE CONNECTION



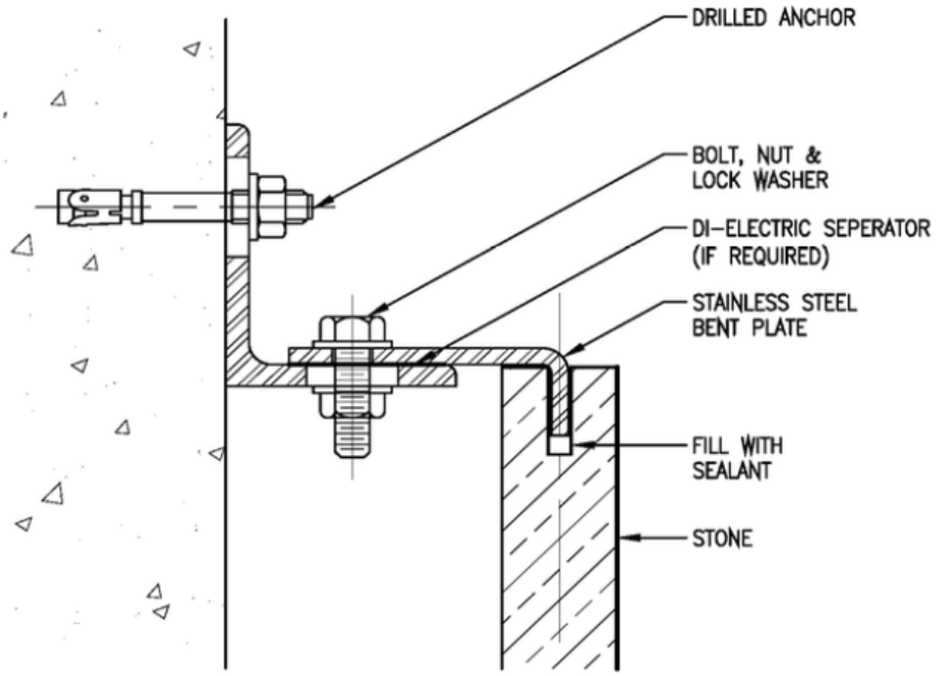
TWO PIECE KERF CONNECTION MID-HEIGHT



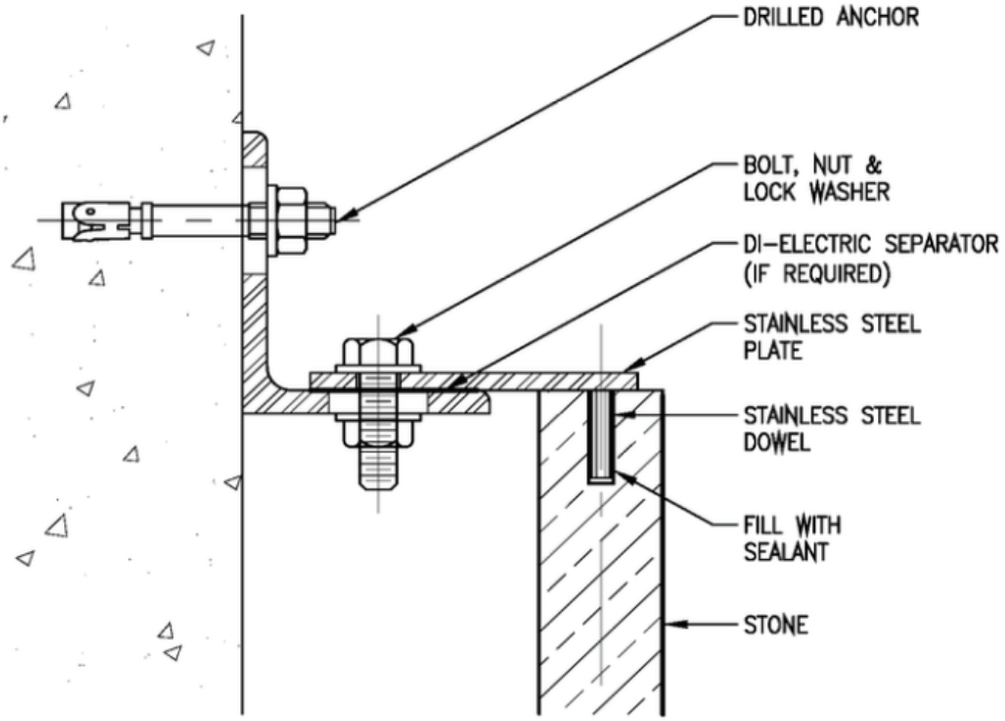
TWO PIECE DOWEL BASE CONNECTION



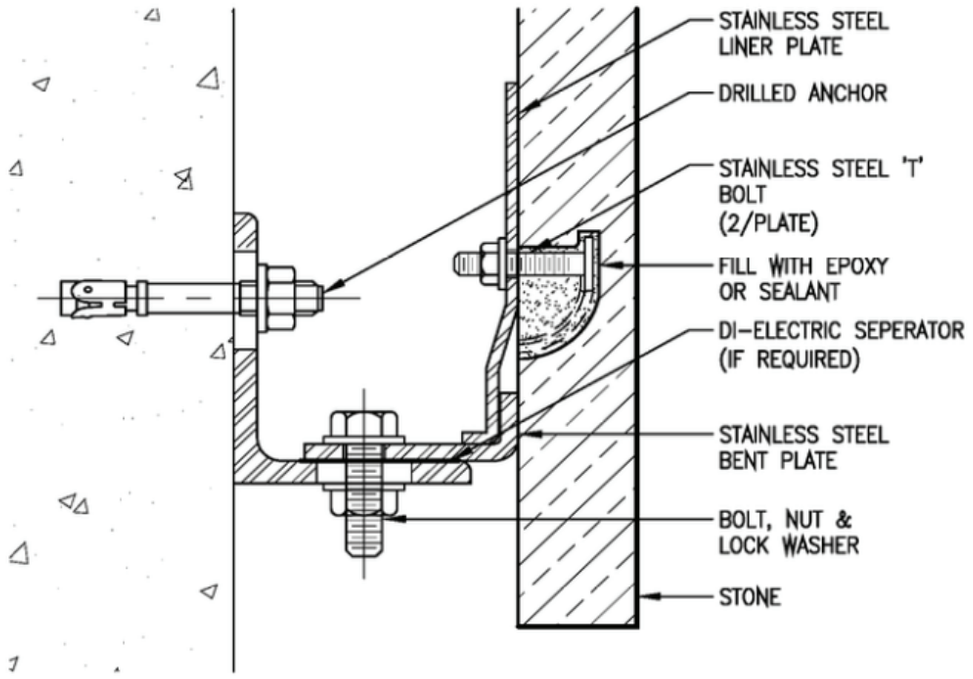
TWO PIECE DOWEL CONNECTION MID-HEIGHT



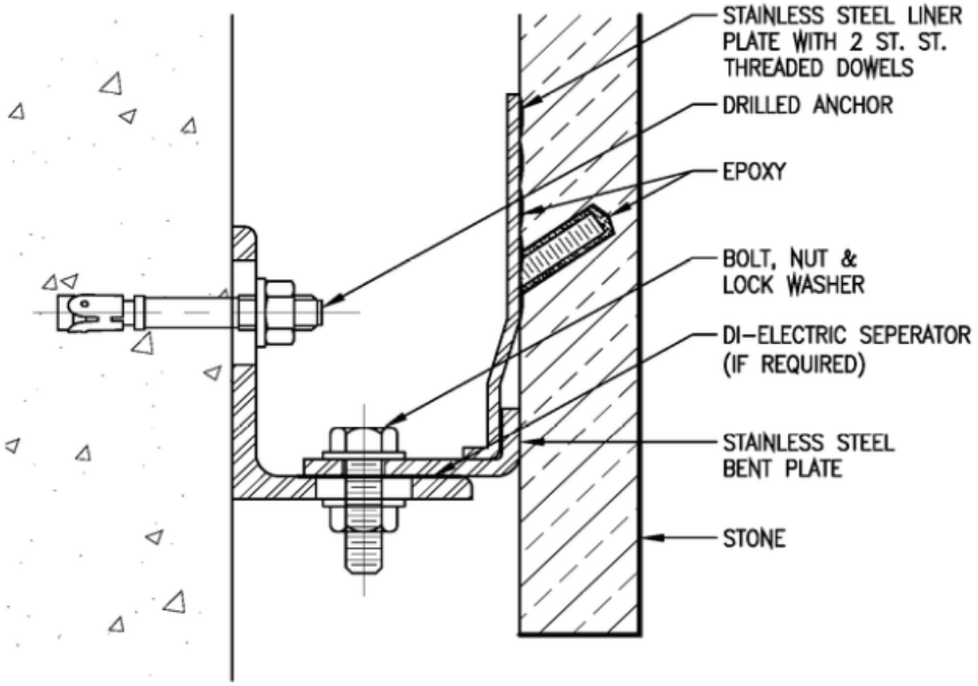
TWO PIECE KERF CONNECTION TOP



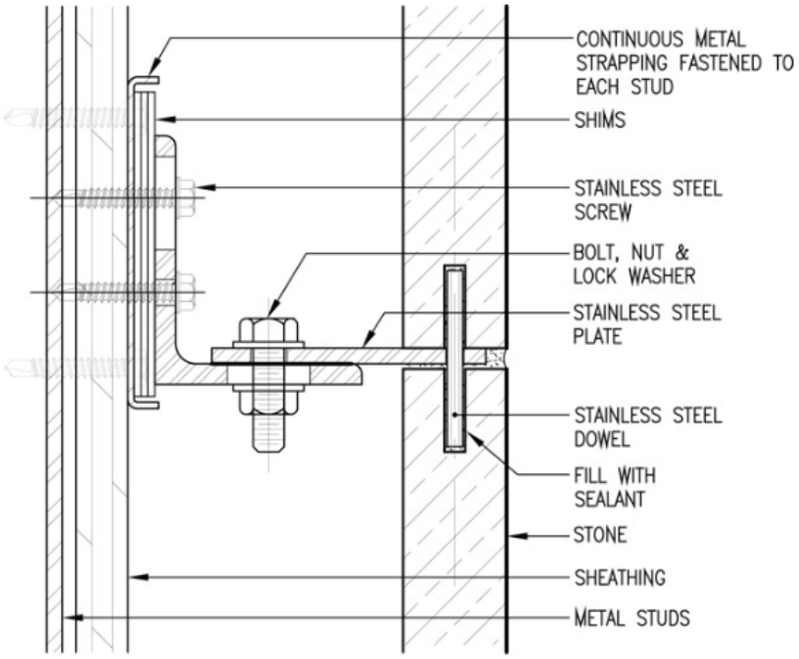
TWO PIECE DOWEL CONNECTION TOP



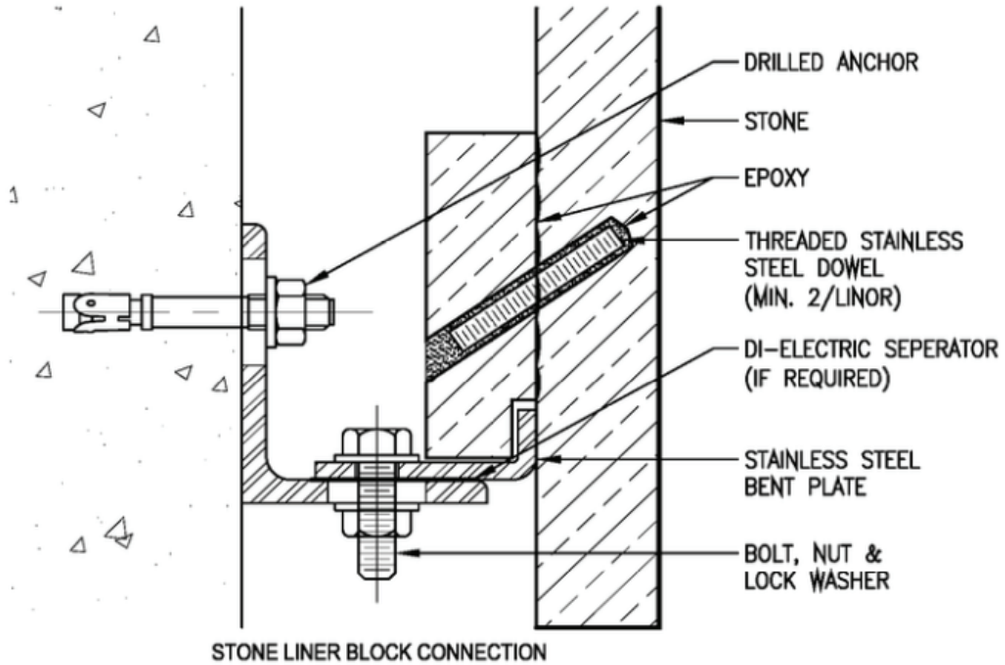
LINER CONNECTION WITH 'T' BOLTS



LINER CONNECTION WITH 'T' BOLTS

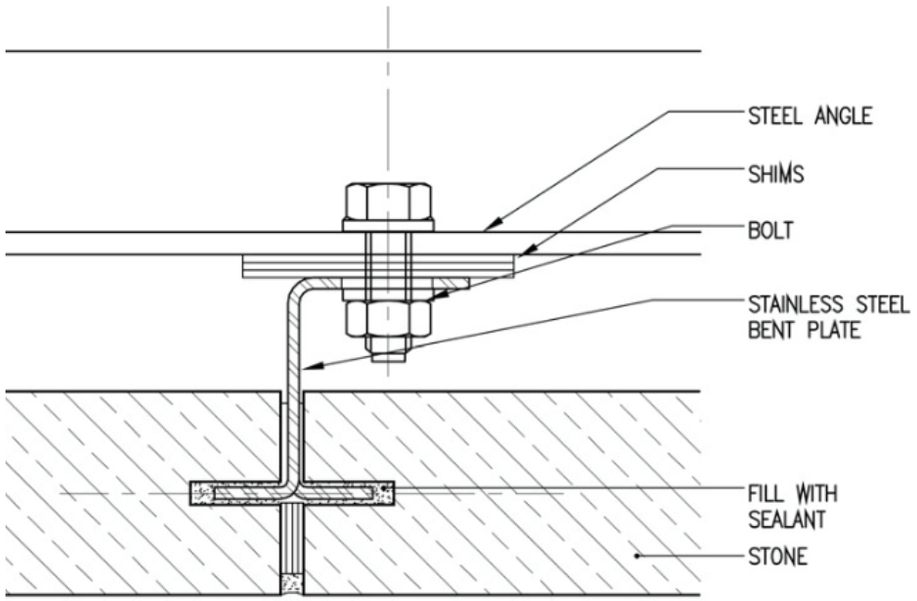


TWO PIECE ANCHOR TO METAL STUD CONNECTION MID-HEIGHT

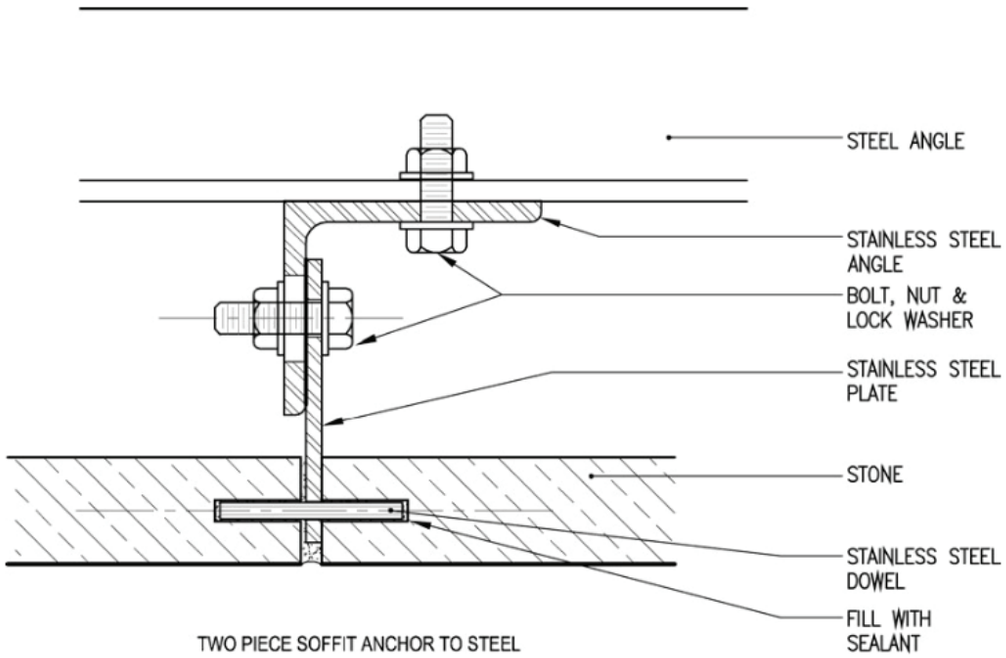


STONE LINER BLOCK CONNECTION

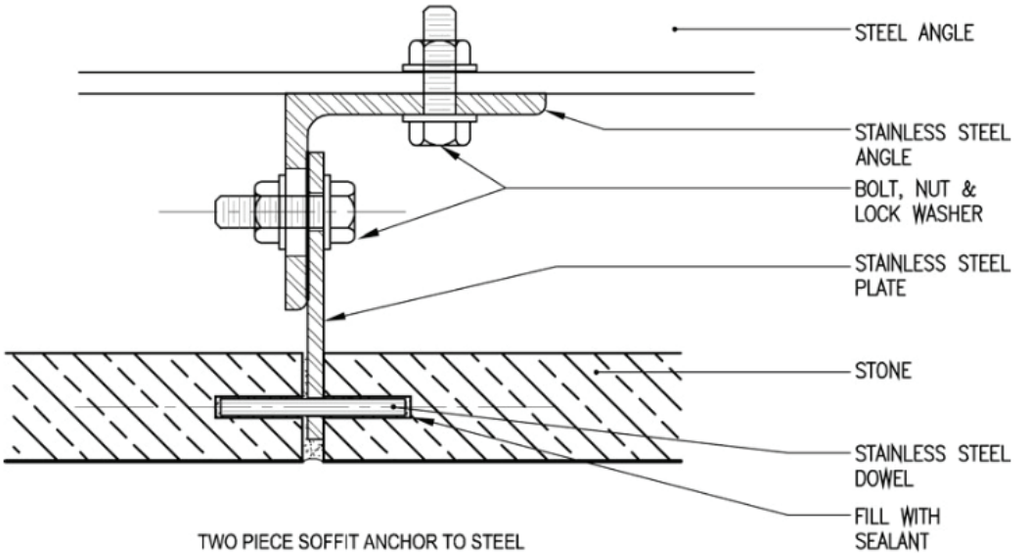
Soffit Connections



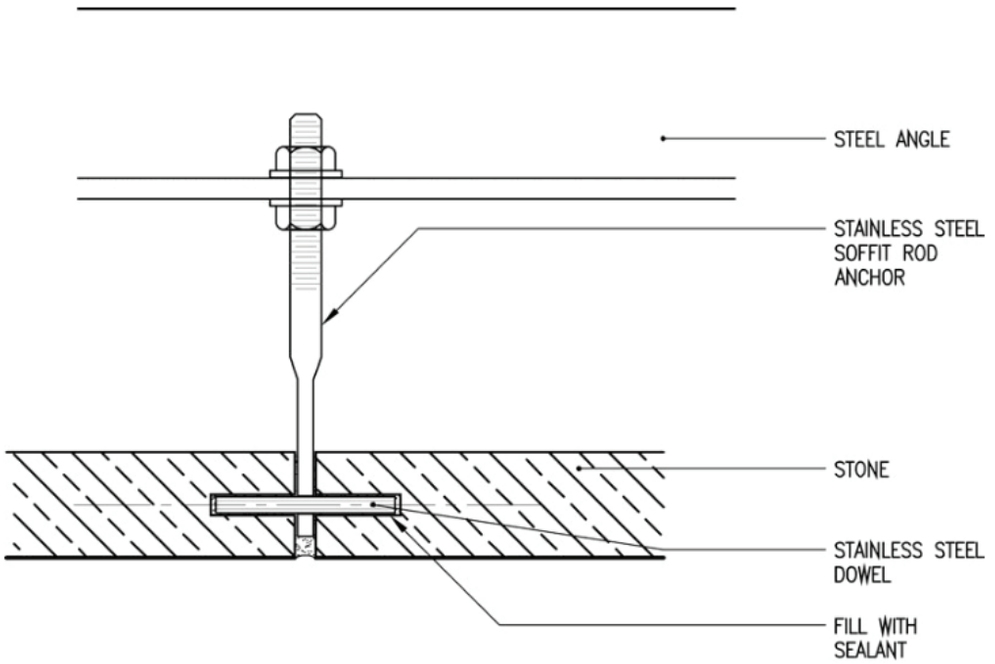
ONE PIECE BOLTED SOFFIT CONNECTION



TWO PIECE SOFFIT ANCHOR TO STEEL



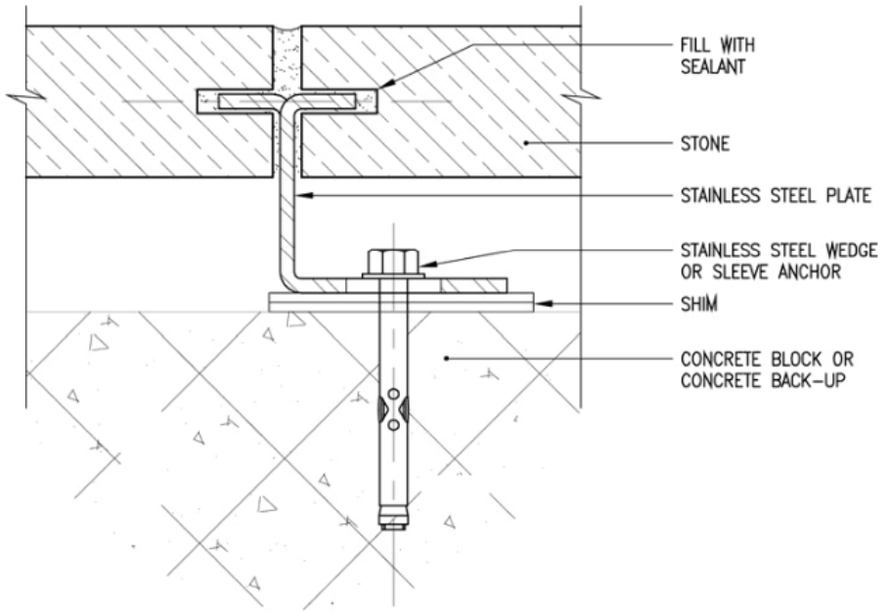
TWO PIECE SOFFIT ANCHOR TO STEEL



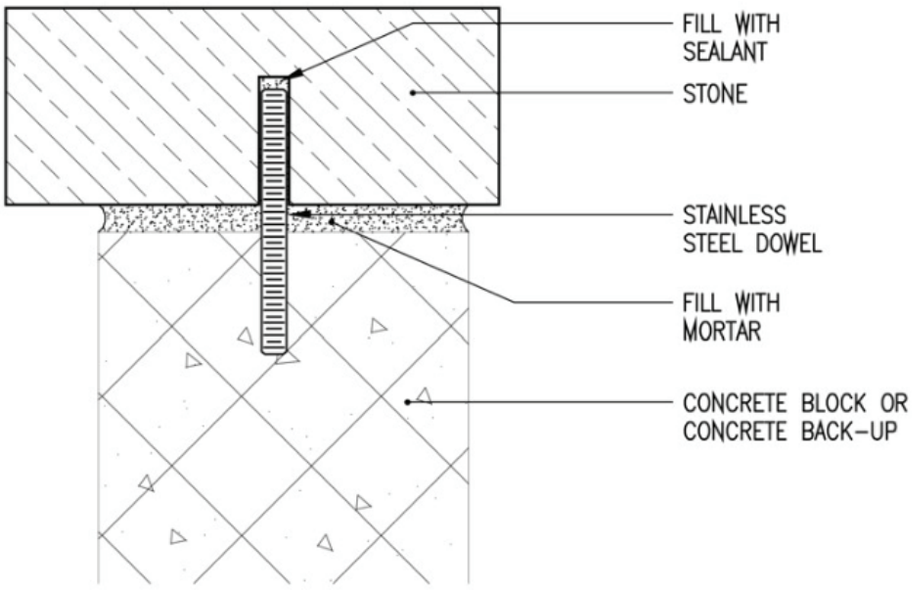
STEEL ROD SOFFIT ANCHOR TO STEEL

Coping Details

Below are a few common coping details. Coping stone could be installed by simply doweling to a concrete parapet and bearing on either shims or a mortar bed. They could also be mechanically anchored at the vertical head joints. Care should be taken to design proper flashing and provide drips where appropriate.



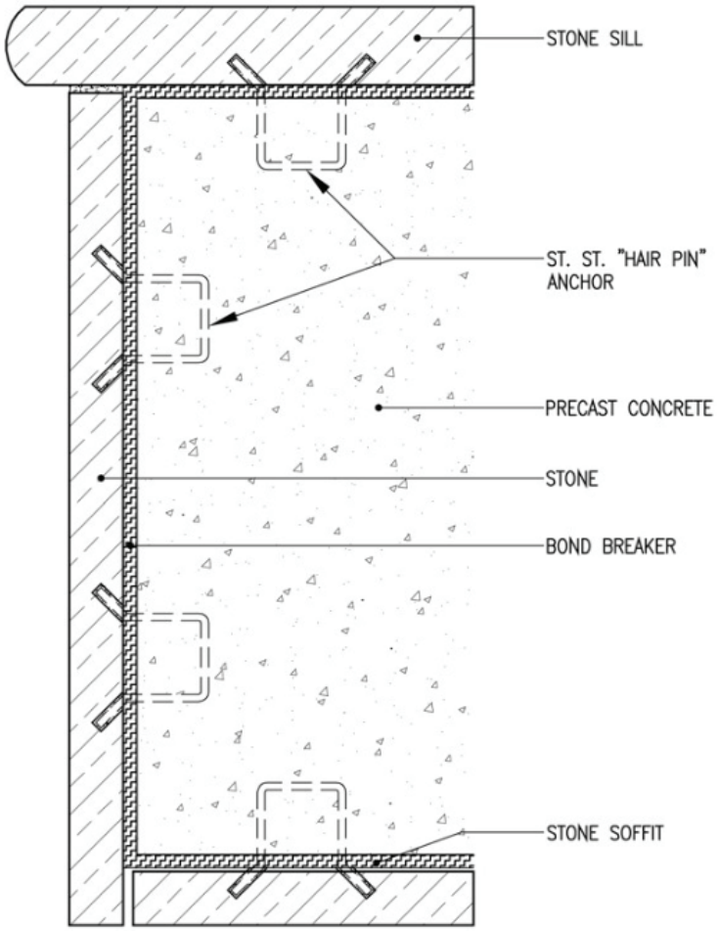
COPING DETAIL



COPING DETAIL WITH DOWEL

Precast

Stone faced precast concrete panels are very common on mid rise buildings. Very close attention must be paid to the stone properties as they relate to concrete. Because the stone is, in most cases, directly anchored to the concrete and separated by a bond break, properties such as thermal expansion and contraction and anchor strength and placement are very important. Below is a sample precast faced panel utilizing hairpin anchor to fasten the stone to the concrete. Other fasteners such as “T” bolts or epoxied opposing pins could also be used to fasten the stones to the concrete.



PRECAST CONCRETE SPANDREL PANEL

Mechanically Anchored – Strut System

Introduction

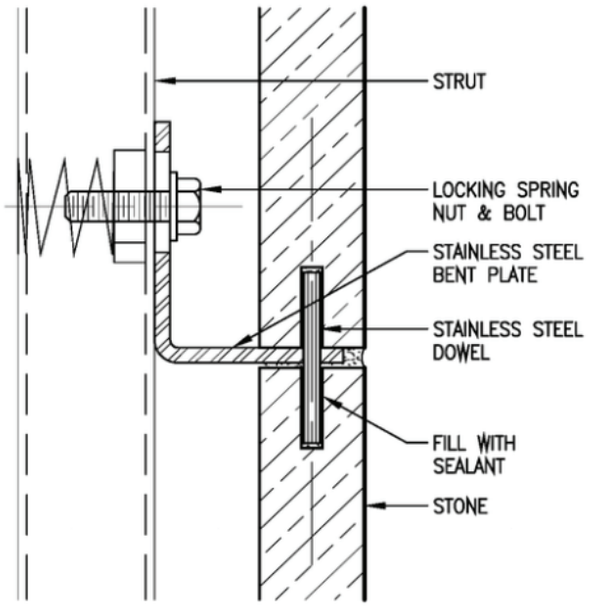
This anchoring option is designed with the same principals as the mechanically anchored standard method with the exception of utilizing a cold formed or extruded channel section referred to as a strut and a locking spring nut that is used to fasten the anchor. Rather than fastening the anchor directly to the substrate, the strut is fastened to the substrate. These struts typically run vertically and are located at the panel 6 mm (1/4 inch) points. Struts can be fastened directly to the substrate or suspended out from the substrate with the use of angles or formed “hat” shaped sections.

Application

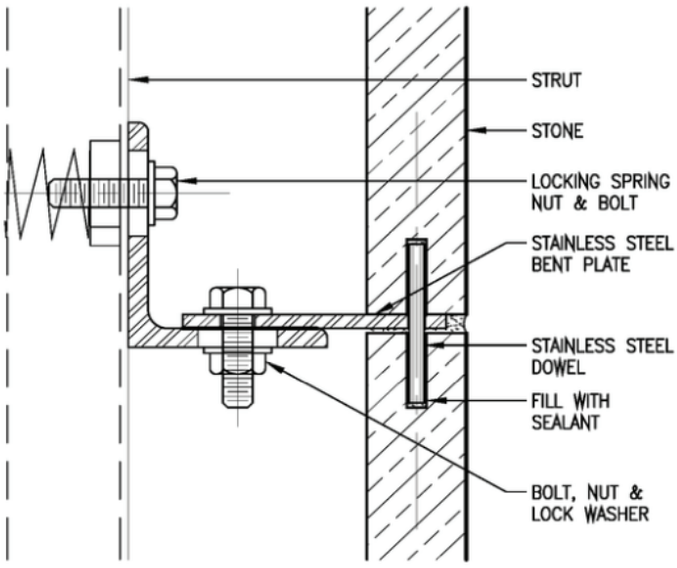
This system can be extremely advantageous when used in the right application. Vertically stacked panels of reasonable size, (610 mm (2 feet) to 1220 mm (4 feet) high and 915 mm (3 feet) to 1525 mm (5 feet) wide) in one plane and with few interruptions from windows or other building elements, are optimal for this system. It can also be advantageous in a true running bond pattern where 6 mm (1/4 inch) points of the stone align.

Substrate

Acceptable substrates include structural concrete, solid masonry or structural steel. Metal stud back is the least preferred substrate because difficulties arise in coordinating stud locations to align with strut requirements. Care must be taken during the design phase to ensure that the vapour barrier and insulation requirements of the building are not compromised. If designing with metal studs, it is advisable to use plywood as a sheathing to help add stiffness to the wall assembly.



ONE PIECE STRUT CONNECTION



TWO PIECE STRUT CONNECTION

Mechanically Anchored – Stacked

Introduction

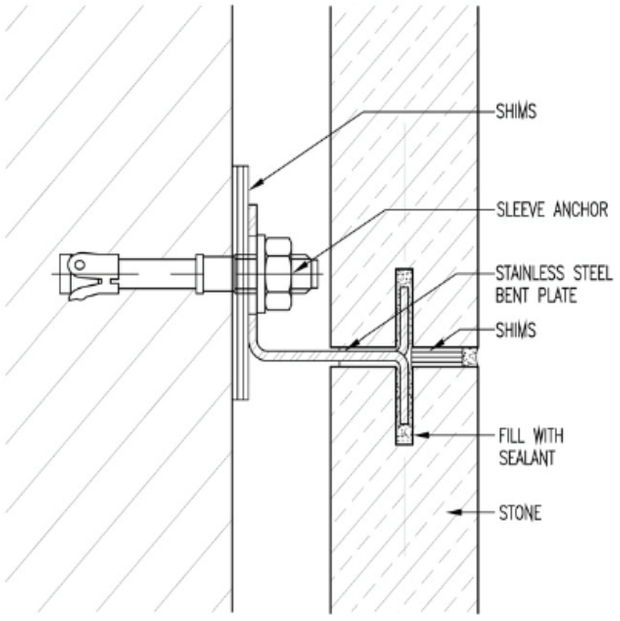
This system is most often used with stone cladding having a thickness greater than 65 mm (2 1/2 inch). It requires that the stone be stacked and bear its load on the stone below it, using anchors or ties to provide lateral support only. For walls extending higher than 3049 mm (10 feet), continuous relieving angles or comparable support must be provided at spacing not exceeding 3960 mm (13 feet). Local code requirements and limitations must be checked prior to using this system.

Application

This system is most often used for interior cladding however, it is also used for exterior walls less than 3049 mm (10 feet) in height and for stone set with full mortar bed joints. For walls greater than 3049 mm (10 feet) in height, the wall is divided into sections with the use of continuous load bearing angles located no greater than 3960 mm (13 feet) apart to carry the load of the stone. For stones greater than 75 mm (3 inch) and set in mortar a masonry type anchor is acceptable. With thinner stones or those set on shims with sealant joints, the strap anchor or tie must engage the stone into a hole or kerf. Flashing and weep holes must be provided at all continuous support locations.

Substrate

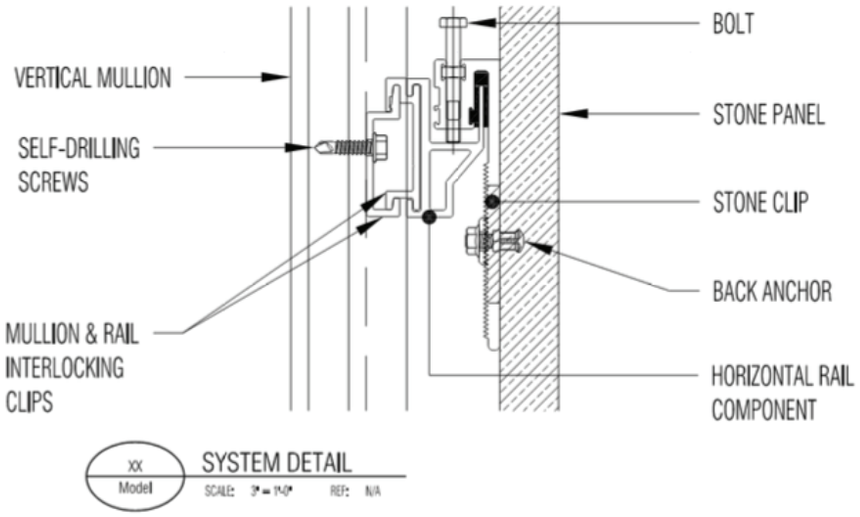
Acceptable substrates are structural concrete, solid masonry or structural steel and metal studs. Metal stud back is the least preferred substrate as it is often difficult to get the load capacities required for continuous relieving angles. The exterior sheathing is often required to be interrupted at the relieving angle so it could bear directly onto the metal studs. This can pose some difficulties with ensuring continuity of the air and vapour barriers. It is often common to see the relieving angle located at the floor levels anchored into the concrete and the lateral anchors fastened to the studs. Care must be taken during the design phase to ensure that the vapour barrier and insulation requirements of the building are not compromised.

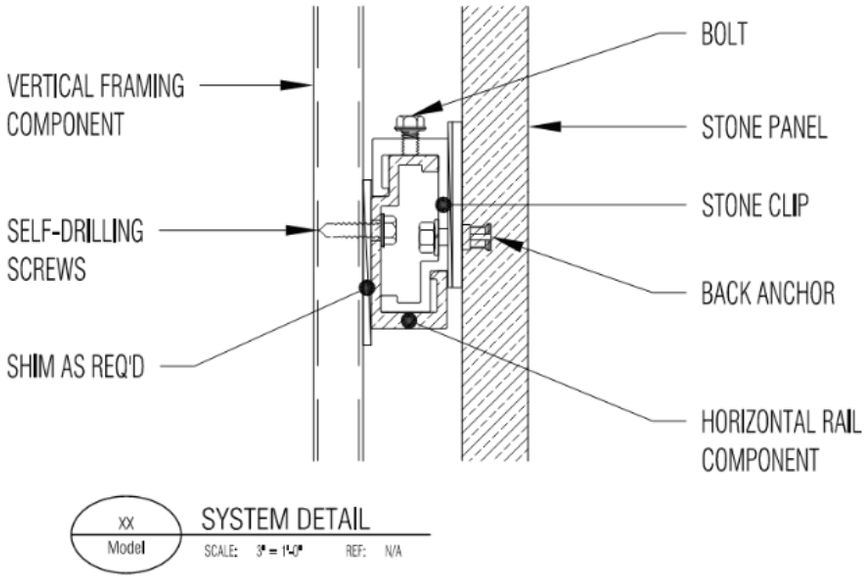


ONE PIECE DOWEL BASE CONNECTION

Exterior Aluminum Sub-Frame Systems

Many proprietary custom aluminum extruded sub-frame systems comprising of vertical and/or horizontal members have been developed to serve as an attachment assembly for stone and porcelain in rainscreen applications. These systems often minimize penetrations through the insulation reducing thermal bridging and are often located within the air cavity of the wall assembly.





INTERIOR STONE - VERTICAL APPLICATIONS

An interior substrate for vertical cladding can be defined as any area that is shielded from the elements and is temperature controlled within a range of 10 to 30 Celsius.

Natural stone continues to be one of the most popular forms of interior cladding for prestigious structures in both commercial and residential applications. For the purpose of this guideline, stone cladding will be referred to as material greater than 19 mm (3/4 inch) in thickness, for use in residential and commercial applications. Other stone products, less than 19 mm (3/4 inch) thick, are addressed in the TTMAC Specification Guide 09 30 00 Tile Installation Manual. Consult and conform to all local building codes and regulations when designing stone cladding. In choosing a cladding system, both the anchoring method and substrate must be reviewed and/or designed in conjunction with each other. Systems exceeding 3659 mm (12 feet) in height must be designed by a structural engineer. The final installation must be able to withstand all design loads and requirements in the National and Local Building codes.

GENERAL INFORMATION

Sampling and Mock-Ups

The stone contractor shall submit samples of all the specified dimension stones to the architect for approval. The sample sizes should be specified by the architect at the time of tender. The number and size of samples should clearly show the colour and shading range that will be acceptable as well as identify extreme veining and/or inclusions. Samples must be unconditionally approved or rejected in their entirety. In some cases, architects and contractors may view and select the actual slabs to be used for the project.

The designer or architect may request a mock up for the purpose of viewing and approving the colour and shading range and to set the standards for fabrication and installation tolerances. Mock-ups can form part of the completed work.

Shop Drawings

Shop drawings must clearly convey all relevant information to the architect, contractor and installer. Relevant information is to include the necessary plans, elevations, sections and details to clearly dimension and detail all stone and its interface with adjacent materials. Drawings must include professional engineer stamped anchor details for fastening of the stone, if required. The architect and contractor are to ensure that all information on the shop drawings has been interpreted properly and approve the dimension information on the drawings. With the lead times required to fabricate stone, providing dimension approval at an early stage will allow for expeditious material procurement and ordering and in turn ensure material is delivered on schedule. Project specifications should clearly indicate the shop drawing requirements and architects should accept nothing less.

Safety Factors

As with any engineered material, safety factors must be included in the design that take into account, material variations, loading conditions, imperfect workmanship, etc. Stone, being a natural product, quarried from the earth, requires a safety factor that will ensure that the allowable stresses in the stone are never exceeded. There as been much discussion on what an appropriate safety should be. Some published material and design codes have related safety factor to the stone type; granite being designed to a safety factor of 3-4, marble to 4-6, and limestone 6-10.

What is becoming more customary in the industry is relating the safety to the variability in the stone testing results. A stone demonstrating very constant testing results (a low coefficient of variation) be designed with a lower safety factor and one with a high coefficient of variation be design with a higher safety of factor.

Availability & Consistency

Each variety of stone has its own range of variation. Some variations are quite subtle, and others can be extreme. When used intentionally, these ranges can make for very creative and appealing application. An example of this is book matching the veining. This requires the slabs to be polished face to face, which is not the norm, therefore if book matching is desired, the slabs must be ordered specifically for that application. Once familiar with the range, precautions should be taken to ensure sufficient quantities to accommodate design requirements. When approving samples, architects and designers must understand that stone is a natural product and there will be subtle differences between quarries, blocks, and in many cases from slab to slab.

Detailing

Since each material has its own unique physical characteristics, each material will respond differently to detailing. Edging, finishes, and panel size must be considered when selecting a cladding material. Some materials, particularly some limestone, have limited slab sizes. Some materials cannot be polished while others can be polished but not flamed. Softer materials and those with larger grain tend to be troublesome when mitering and can pose a problem if crisp straight polished edges are desired.

Location

The intended location of the stone within the interior space must be considered when selecting a stone. Factors such as moisture, exposure to direct sunlight, and soffit use will affect the performance of the stone. If large quantities of the selected stone are required, it is common to expand the acceptable range of the material. In some cases, material will have to be culled into groups of shade ranges and used in particular areas to avoid great variations from one slab to another. Furthermore, material must be procured and reserved well in advance of the detailing to ensure material is available when needed.

Fabrication

Ensure that the fabricator of choice has sufficient experience in preparing stone cladding for interior use. If the fabricator is overseas, compensate for the increased lead-time and order additional material for unexpected changes and/or damage. In some cases, over sizing panels may help compensate for site conditions.

DESIGN COMPONENTS

Fastening Systems

The selection of an anchoring system is dependant on the substrate supporting the stone, the type and thickness of stone, and the forces acting on it. Any of the anchoring systems used for exterior cladding can be used on interior installations where applicable. The requirements for materials and systems used for fastening interior applications are less stringent than those for exterior applications given the controlled environment of interior space.

Refer to Engineering Requirements discussion on page 25.

Thermal Expansion & Contraction

Thermal expansion and contraction in interior environments are often overlooked because of the assumption that temperatures are always relatively constant, unlike the exterior where temperature extremes are experienced. For interior areas such as atriums or spaces with very large windows or skylights, the rays from the sun onto the surface of the stone can result in the stone becoming warm and in cases of very dark materials, even hot. This can result in considerable thermal expansions and if proper precautions are not taken can cause serious damage. This is most significant in tall multi-storey walls or columns. Very long continuous horizontal walls may also be affected if exposed to direct sunlight.

Substrate

There are numerous acceptable substrates used for the installation of interior wall cladding. When designing or selecting a substrate, all design loads, including but not limited to internal air pressures, dead load of the stone and any fixtures that may be fastened to the wall must be accounted for. The substrate must be designed stiff enough to limit the deflections to a maximum of L/360. In cases with large panels and tight grouted joints, it is advisable to design to deflections of L/480. The substrate provided should be continuous and preferably concrete, block or plywood clad steel frames or metal studs. A continuous substrate allows for conventional wire and plaster installation which is most preferred when dealing with interior installations. An engineer should review all interior wall cladding extending over 3049 mm (10 feet).

Wall Substrate Applications

High rise construction today most commonly uses metal studs and gypsum drywall paneling as the substrate for interior walls. This, along with wood stud framing, is also used throughout the new home industry. The use of natural stone in residences has increased dramatically in recent years mostly due to its inherent value. Homeowners have come to appreciate its beauty, durability and long lasting performance. Many bathrooms and showers are being clad with 19 mm (3/4 inch) thick marble, granite and limestone panels. Gypsum drywall provides for a suitable backup surface for the installation of either a thin-set or conventional wire and plaster installation. Gypsum drywall is not recommended for wet areas such as showers, steam rooms, tub surrounds or any other moist environments. For these areas, a more suitable and moisture resistant substrate must be provided. It is quite common to use a cementitious backer unit (CBU). Another method, not as commonly used, is to provide a cement mortar bed in lieu of drywall or CBU. This traditional method provides a sturdy and ideal surface where installation challenges may present highly custom shaped walls or curved surfaces.

SUBSTRATES

This is the most preferred backup for both exterior and interior cladding and is suitable for all methods of interior installation. It provides a solid, continuous and rigid substrate where anchors can be placed where required. Anchor capacities are highest when installed into concrete.

Masonry

Masonry substrate is one of the oldest and most common forms of structural support for stone cladding. Many historical stone clad buildings throughout the world used a wire and plaster installation fastened directly to terracotta blocks or tiles in a similar fashion to the conventional wire plaster method still used today.

Terracotta tiles or blocks are still common in Europe, but are rarely used in North America. It is more customary to see concrete masonry units (CMU) of 140 mm (5-1/2 inch), 190 mm (7-1/2 inch), 240 mm (9-1/2 inch) or 290 mm (11-1/2 inch) in size. It is generally recommended that CMU be either solid filled or 75% solid units. Brick is also acceptable, provided it is not a veneer and is either the structural substrate or structurally fastened to the substrate.

Structural Steel

Structural steel frames or sub-frames are acceptable substrates for interior stone cladding. In the case of mechanically anchored stone, the frames are adequate without any sheathing, provided they are designed by the stone engineer to coincide with the stone anchor locations. If the frames are not designed to accept stone anchors, costly additional framing may result. If using frames for standard set method or thin-set, a continuous sheathing of plywood, cement board or gypsum drywall must be provided.

Structural Metal Studs

The use of structural studs as backup for stone cladding has become much more common. For most interior installations where stone is stacked, a properly designed metal stud wall with continuous sheathing is an acceptable substrate. As with any substrate, it is essential to limit lateral load deflections to a maximum of L/360. Studs should be a minimum thickness of 16ga. Recommended sheathing is 19 mm (3/4 inch) plywood, 12 mm (1/2 inch) CBU, coated glass mat backer board or gypsum drywall. Anchors are typically fastened through the sheathing and into the structural stud. The sheathing provides a backing for the plaster or adhesive setting spots.

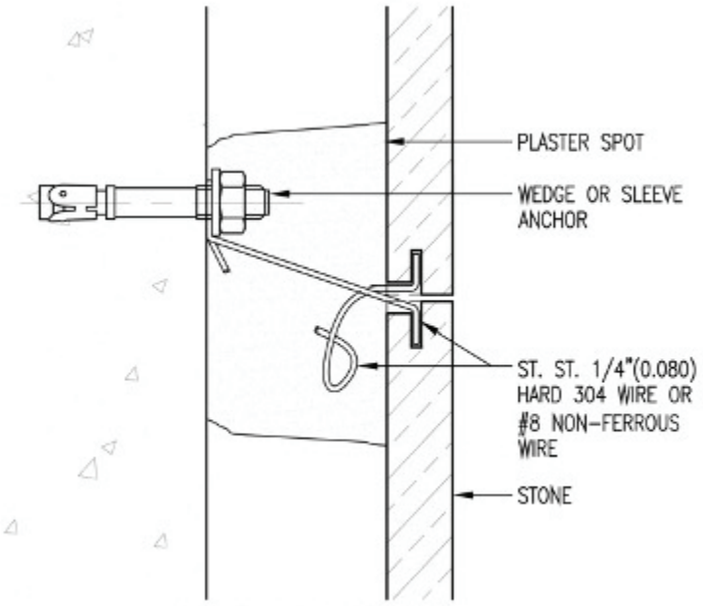
Metal studs are not recommended for mechanically anchored individually supported installations.

Installation Systems

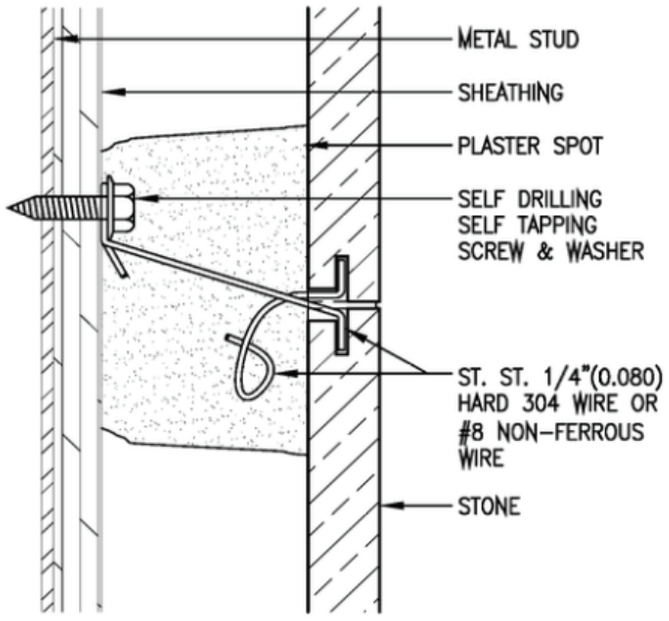
When selecting a cladding installation system, both the anchoring method and substrate must be reviewed and/or designed in conjunction with each other. Systems exceeding 3049 mm (10 feet) must be designed by a structural engineer.

Standard Set (Conventional Wire and Plaster)

The standard set installation method of installation which utilizes plaster and wire has been used successfully for hundreds of years. This method of installation is most preferred when installing slab material on interiors. The fundamentals of the engineering behind this system are quite simple. A wire is engaged into a drilled hole in the stone and is fastened to the substrate while being embedded into fresh molding plaster or plaster of Paris. Once the plaster sets up (within minutes) the wire resists any negative lateral loads while the plaster spots resist positive lateral loads applied to the wall.



WIRE & PLASTER ON CONC. OR BLOCK



WIRE & PLASTER ON METAL STUD

Application

The system is extremely versatile for all forms of interior cladding applications. It is best suited for 19 mm (3/4 inch) and 32 mm (1-1/4 inch) thick panels where the setting space is no greater than 100 mm. For walls higher than 3049 mm (10 feet), a relieving angle is recommended to support the weight of the panels above that level.

Substrate

All substrates mentioned are acceptable for this method of installation. Concrete, CMU, sheathed structural frames and sheathed metal studs are all acceptable.

MECHANICALLY ANCHORED - STANDARD

Introduction

A mechanical anchor can be classified as a single or multi component system designed to transfer the forces acting on the stone panel to the substrate. Anchors must independently support the load of each stone panel and not transfer the weight of the upper panel onto the panel below it. This method is often referred to as hand set. The preference for both engineers and installers is to have two anchors bottom and two top located at quarter points. Typically, each anchor is designed to resist both vertical and lateral loads and is located in the panel joints, so it engages two panels. The anchor supports and laterally restrains the upper panel providing lateral support for the lower panel engaging the stone with either a pin or “split tail” plate. With a pin, the stone requires a hole approximately 2 mm (1/16 inch) greater in diameter than the pin be drilled into the stone’s edge. With the split tail plate, the stone requires a “kerf” which is a saw cut in the edge of the stone approximately 2 mm (1/16 inch) wider than the thickness of the plate. These anchor holes or kerfs are filled with non-staining sealant. The sealant serves a few functions; it prevents moisture build up, provides a cushion between the stone and the anchor and stabilizes the connection preventing any movement within the anchor.

Application

Although most commonly used for exterior applications, anchors are often used for larger interior areas such as atriums or very large interior spaces where the stone cladding extends much higher than 3049 mm (10 feet). In these cases, the interior stone is installed similar to the requirements of an exterior mechanically set application. It is recommended that 32 mm (1-1/4 inch) thick stone be used for this type of installation.

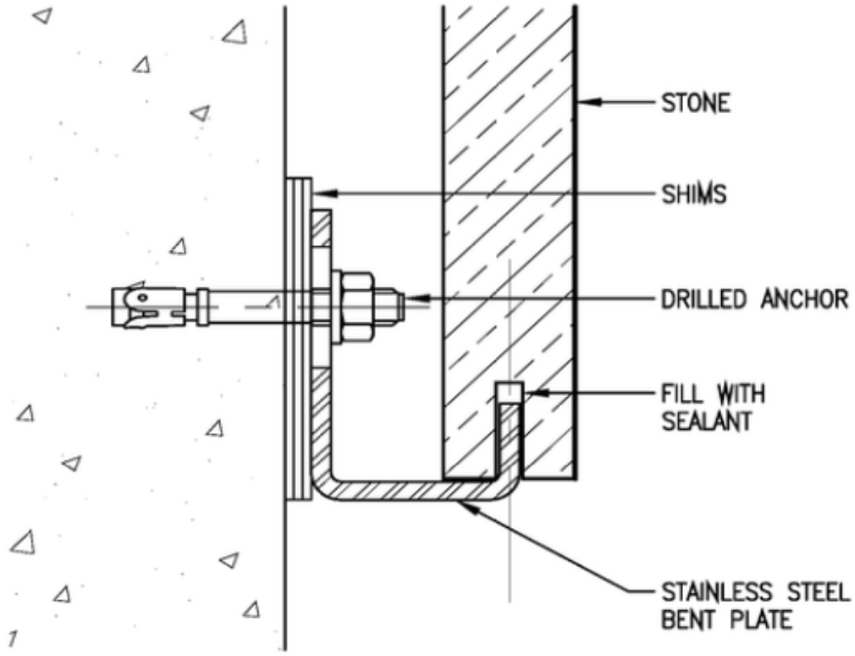
Substrate

Acceptable substrates include structural concrete, solid masonry or structural steel. Metal stud substrate used in load bearing anchoring applications is not recommended. Difficulties arise in coordinating stud locations to align with anchor requirements. Anchoring through the sheathing and achieving adequate support is often difficult and many building codes do not permit the use of self drilling screws to support stone cladding requiring the use of bolts. Bolting through metal studs with sheathing becomes a very labour intensive endeavor and requires access to the back of the wall.

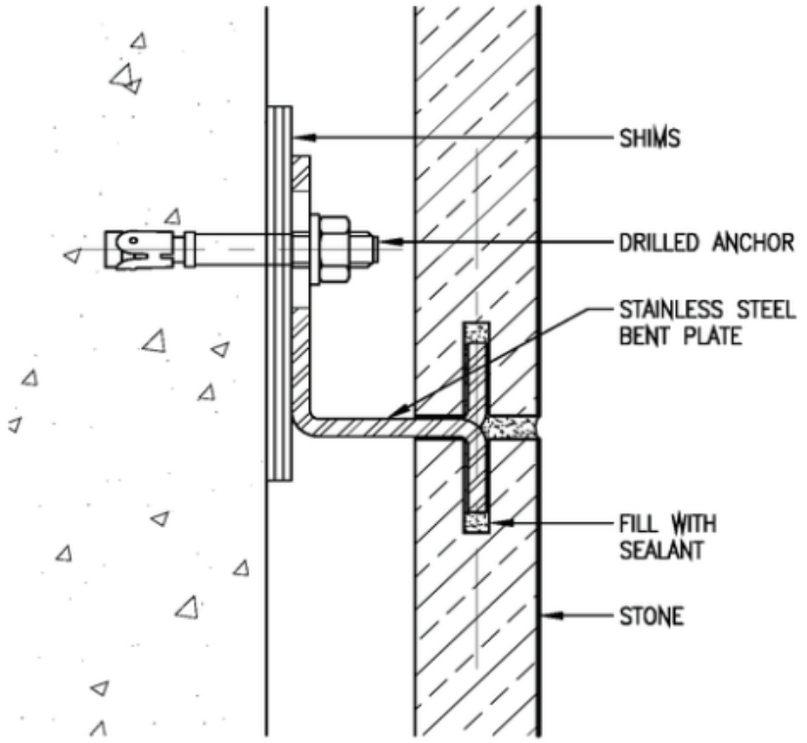
There are two basic anchor types.

“One Piece Anchor”

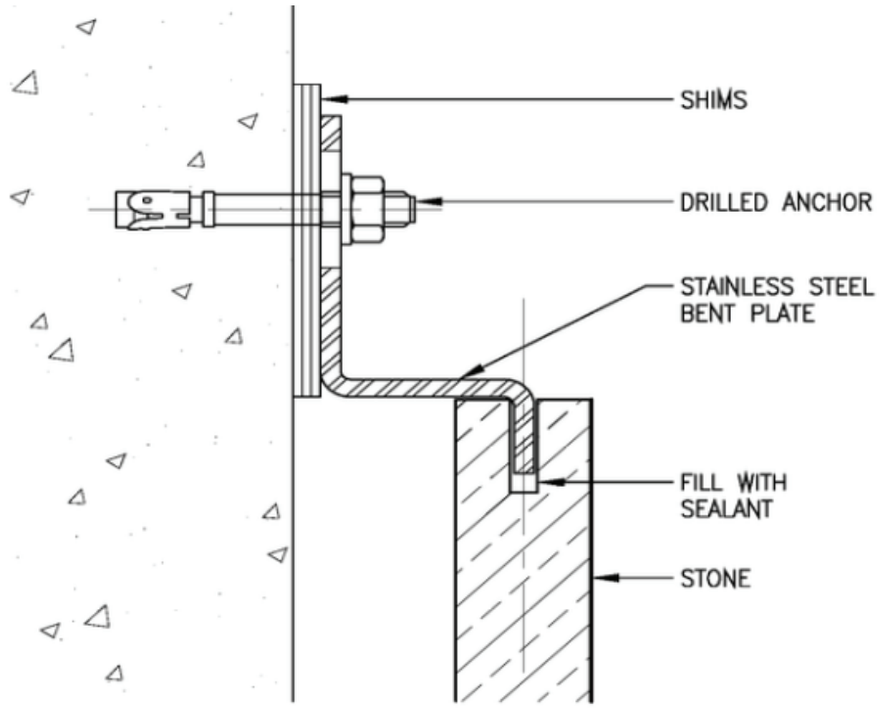
Referred to as a one piece anchor, it does consist of a stainless steel plate and a fastener. The fastener can be a wedge or sleeve anchor if connecting to concrete or block respectively, or a bolt or self drilling screw if connecting to steel sub-frames or metal studs. A one piece anchor is used when the cavity size is less than 65 mm (2-1/2 inch). This anchor offers little adjustment in and out and requires the substrate to be very accurate. Stone installers are often forced to site verify the accuracy of the substrate before ordering anchors.



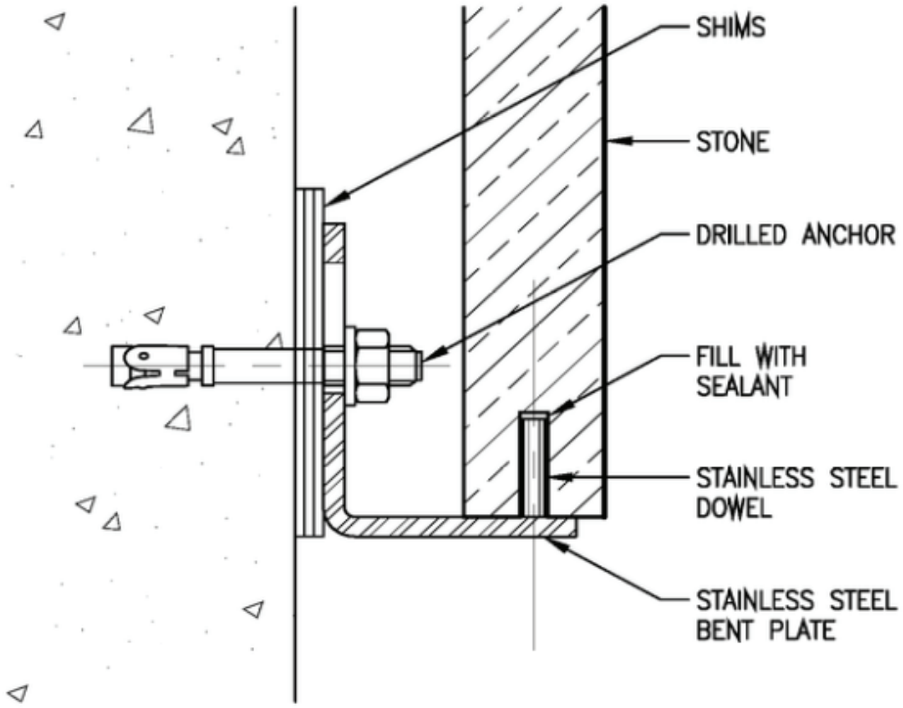
ONE PIECE KERF BASE CONNECTION



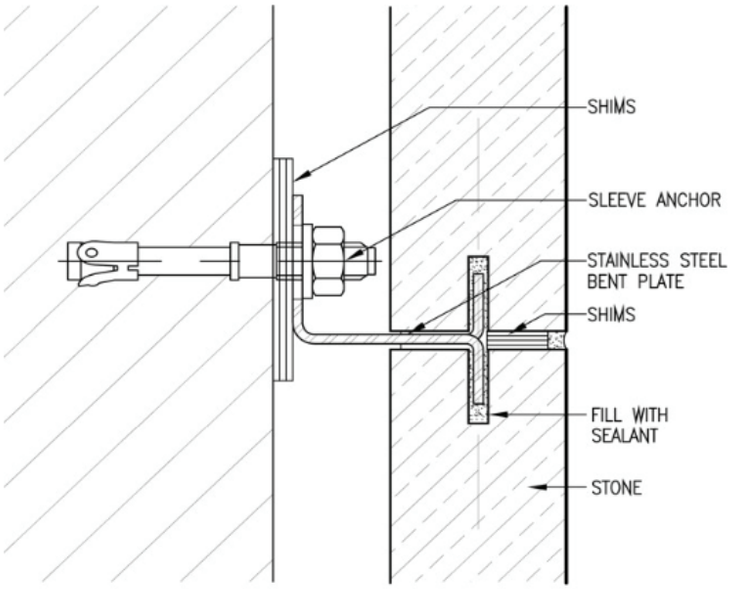
ONE PIECE KERF MID HEIGHT



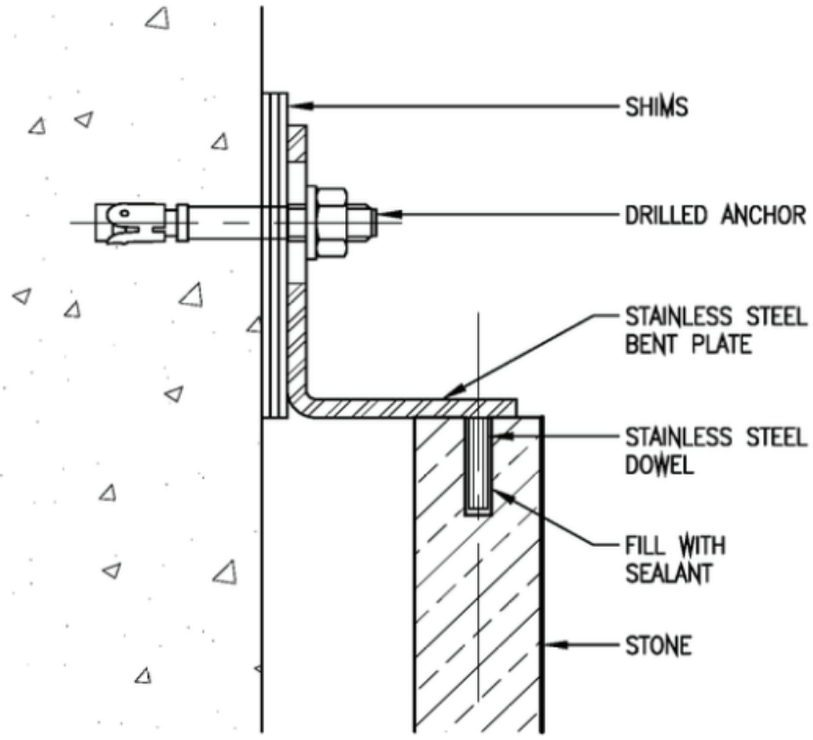
ONE PIECE KERF BOTTOM



ONE PIECE DOWEL BASE CONNECTION



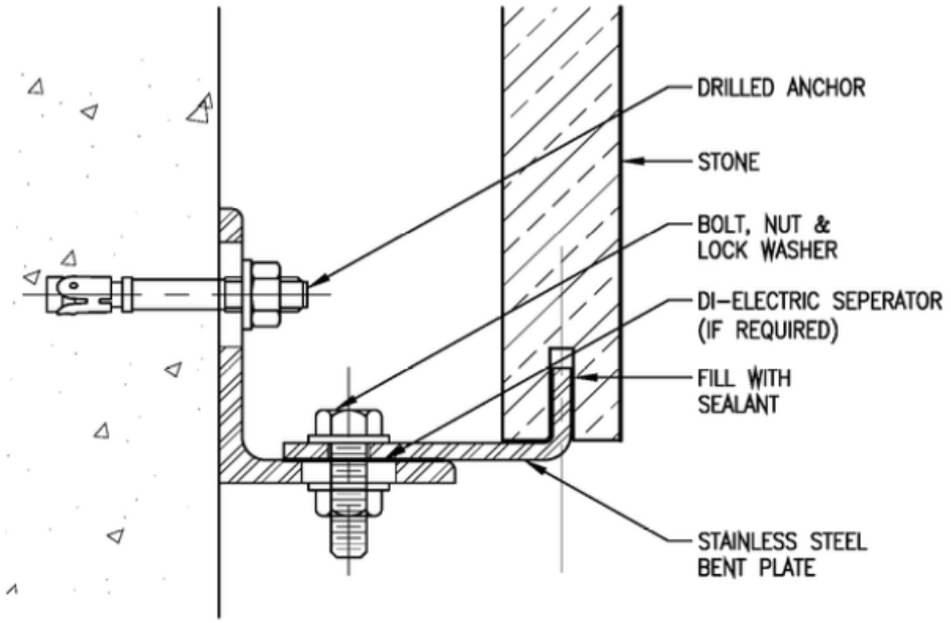
ONE PIECE DOWEL MID-HEIGHT CONNECTION



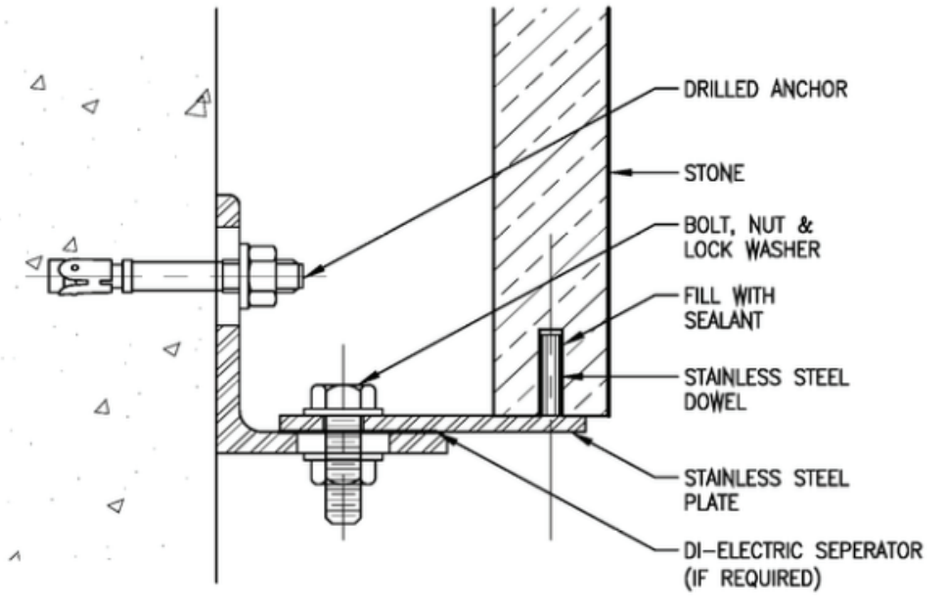
ONE PIECE DOWEL CONNECTION TOP

“Two Piece Anchor”

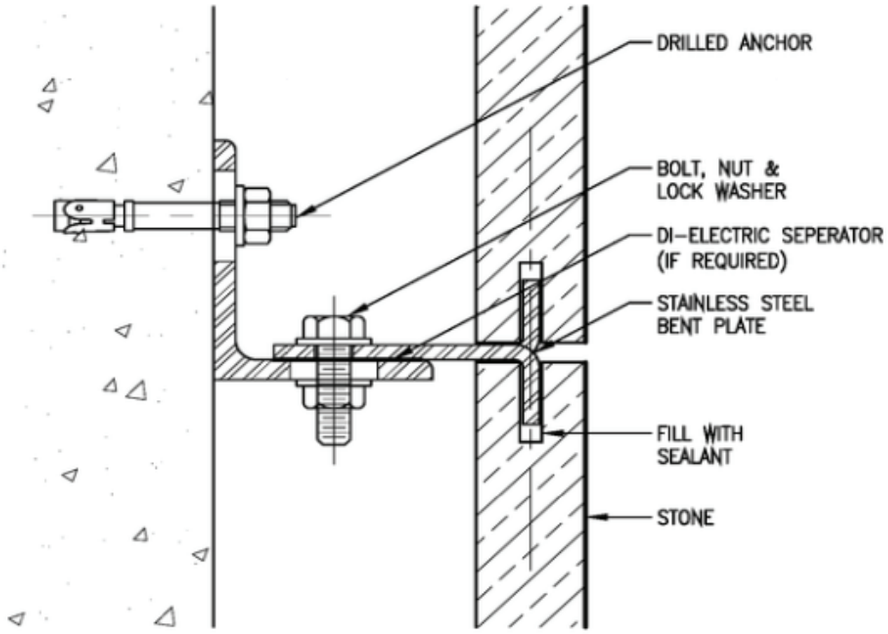
This anchor consists of an angle and a plate connected with a bolt and fastened to the substrate like the one piece anchor. This anchor can only be used with cavity spaces greater than 65 mm (2 1/2 inch) and offers much greater adjustment. Both the angle and plate can be fabricated with slots at the bolt and fastener locations offering adjustment vertically and horizontally.



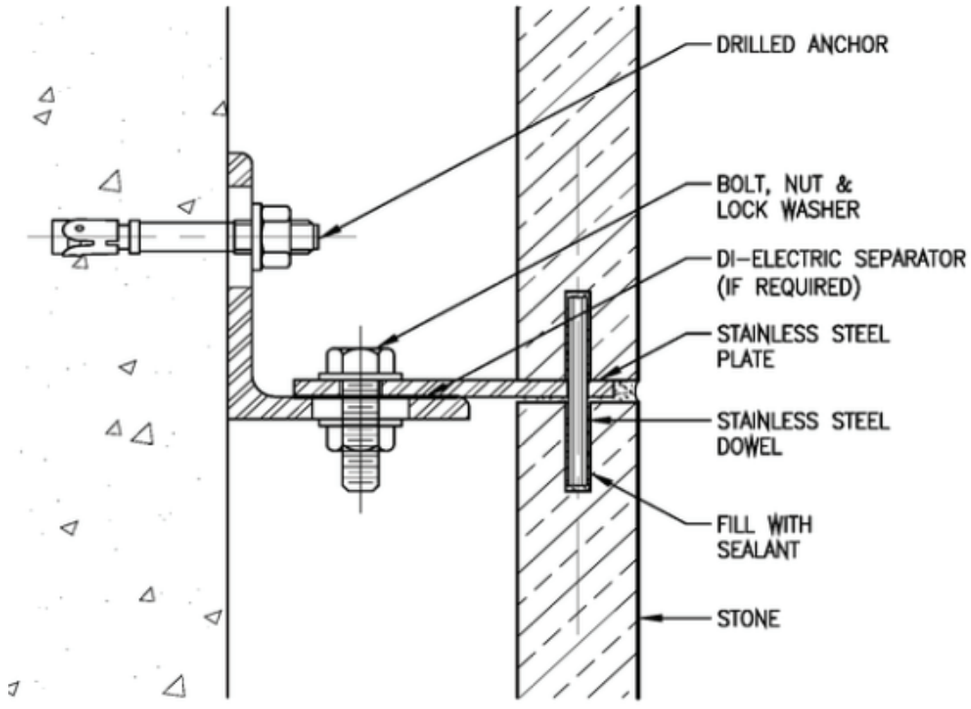
TWO PIECE KERF BASE CONNECTION



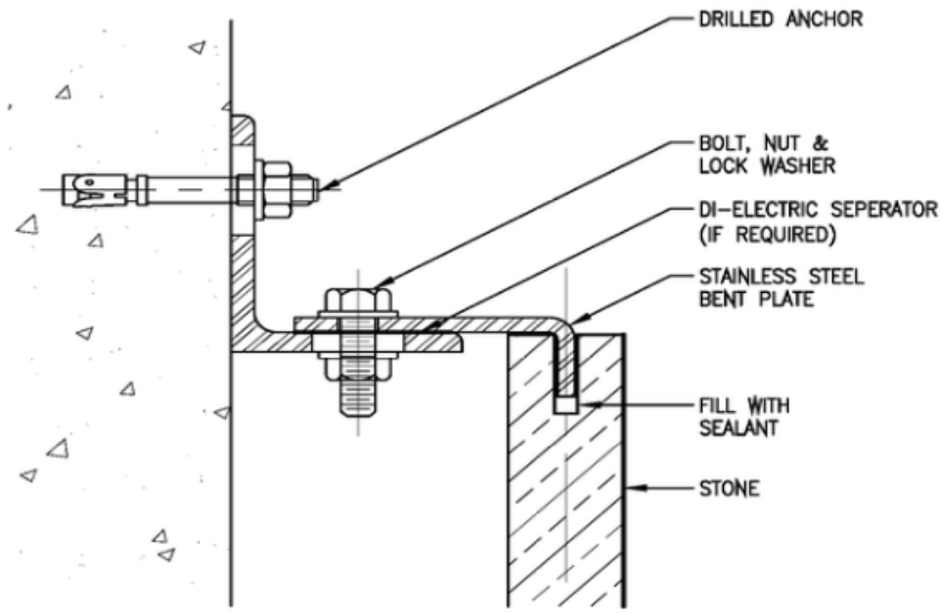
TWO PIECE DOWEL BASE CONNECTION



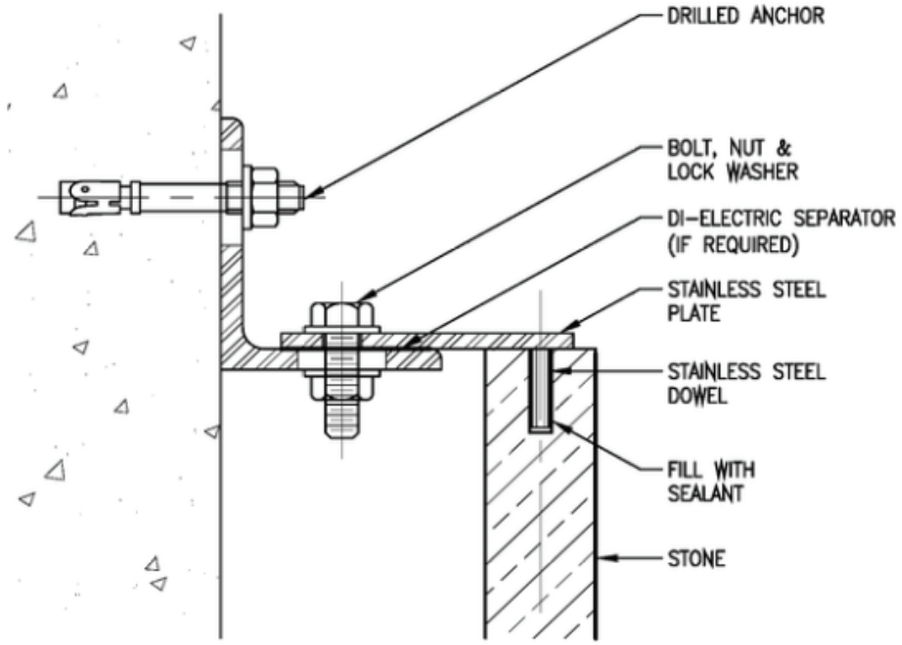
TWO PIECE KERF CONNECTION MID-HEIGHT



TWO PIECE DOWEL CONNECTION MID-HEIGHT



TWO PIECE KERF CONNECTION TOP



TWO PIECE DOWEL CONNECTION TOP

STACKED MECHANICAL

Introduction

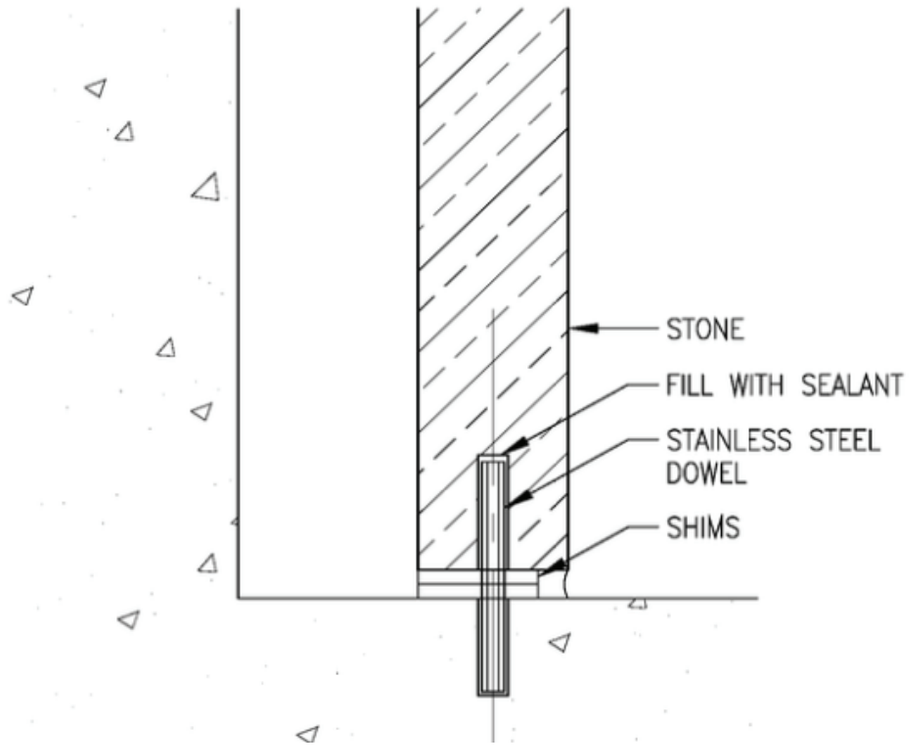
This system adopts the same principals as the standard set method; however instead of wire plaster anchoring the stone, a mechanical one or two piece anchor is used to restrain the stone laterally. Unlike the mechanical anchored – standard, these anchors are only designed to resist lateral loads. Vertical loads of the stone are transferred from stone to stone and bear on either a floor or relieving angle.

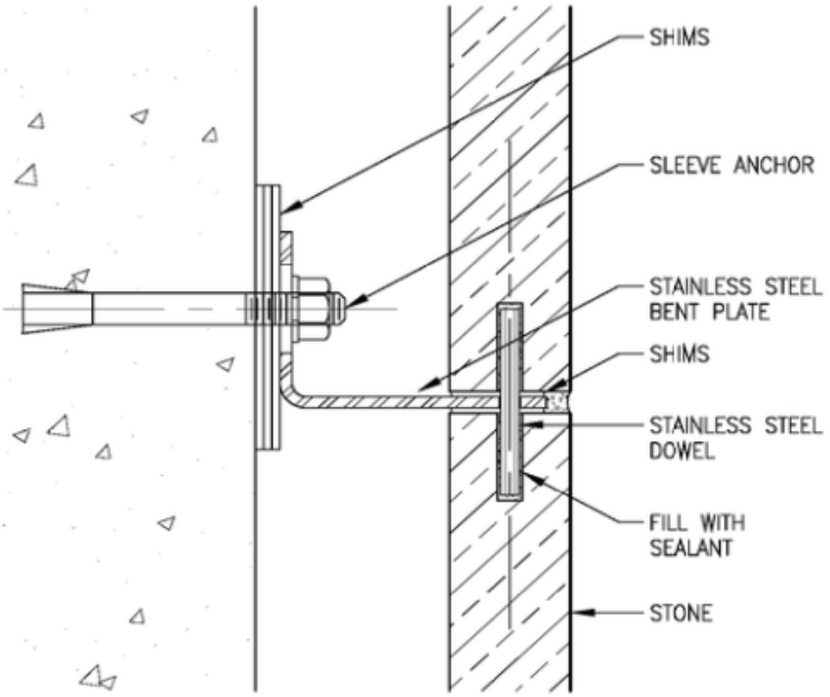
Application

This system would typically be used for 32 mm (1-1/4 inch) thick cladding or greater. When dealing with small cavity spaces a wire and plaster installation is generally preferred. If the cavity space is large or the backup is not suitable for wire and plaster this system may be used. As with any mechanically anchored system, it must be engineered as the frequency and location of anchors are dependant on the stones properties, the panel size and the type of substrate.

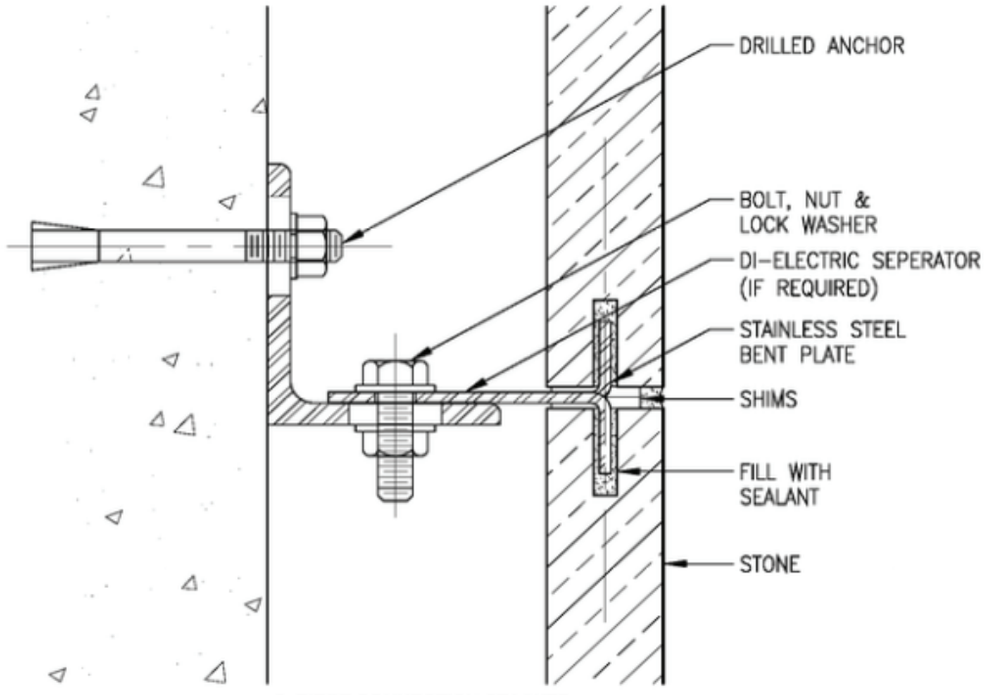
Substrate

All of the substrates mentioned are acceptable for this method of installation. Concrete, CMU, sheathed or unsheathed structural frames or metal studs are all acceptable.





1 PIECE CONNECTION STACKED



2 PIECE CONNECTION STACKED

INTERIOR STONE - HORIZONTAL

For the purpose of this manual, stone flooring will be classified as material that is greater than 19 mm

(3/4 inch) in thickness for the use in residential and commercial applications. For stone products less than 19 mm (3/4 inch), refer to TTMAC Specification Guide 09 30 00 Tile Installation Manual. In selecting an appropriate flooring material, many factors must be carefully examined and taken into consideration. These factors have been noted and assembled in Appendix A, which provides a quick reference guide in aiding in the selection of stone for interior flooring. Consultation with a TTMAC supplier and/or contractor prior to finalizing stone selection can prove to be very beneficial.

GENERAL INFORMATION

Sampling and Mock-Ups

The stone contractor shall submit samples of all the specified dimension stones to the architect for approval. The sample sizes should be specified by the architect at the time of tender. The number and size of samples should clearly show the colour and shading range that will be acceptable and identify extreme veining and/or inclusions. Samples must be unconditionally approved or rejected in their entirety. In some cases, architects and contractors will view and select the actual slabs to be used for the project.

The designer or architect may request a mock up for the purpose of viewing and approving the colour and shading range and set the standards for fabrication and installation tolerances. Mock-ups can form part of the completed work.

Shop Drawings

Shop drawings must clearly convey all relevant information to the architect, contractor and installer. Relevant information is to include the necessary plans, sections and details to clearly dimension and detail all the stone and its interface with adjacent materials. The architect and contractor are to ensure that all information on the shop drawings has been interpreted properly and approve the dimension information on the drawings. With the lead times required to fabricate stone, providing dimension approval at an early stage will allow for expeditious material procurement and ordering and in turn ensure material is delivered on schedule. Project specifications should clearly indicate the shop drawing requirements and architects should accept nothing less.

Availability & Consistency

Each variety of stone has its own particular range of variation. Some variations are quite subtle, and others can be extreme. Once familiar with the range, precautions should be taken to ensure sufficient quantities to accommodate design requirements. When approving samples, architects and designers must understand that stone is a natural product and there will be subtle differences between quarries, blocks, and in many some cases from slab to slab.

Detailing

Since each material has its own unique physical characteristics, each material will respond differently to detailing. Finishes and panel size must be considered when selecting a flooring material. Some materials, particularly some limestones, marbles and slates have limited slab sizes. Some materials cannot be polished when others can be polished but not flamed.

Fabrication

Ensure that the fabricator of choice has sufficient experience in preparing stone for the intended use. If the fabricator is overseas, compensate for the increased lead-time and order additional material for unexpected changes and/or damage. In some cases, over sizing panels may help compensate for site conditions.

DESIGN COMPONENTS

Setting Systems

The setting systems for horizontal stone applications vary widely depending on the stone material, the setting space, the setting material selected and the substrate. Particularly with interior installations, the available substrates and setting material combinations are endless given that the weather and thermal factors are usually not present.

Physical Properties - Stone

When designing with stone one must be aware of the physical properties of the stone and its abilities to meet the requirements of the design. The physical requirements for stone in horizontal interior applications are quite different than those for cladding or exterior applications. Properties such as flexural strength and freeze thaw properties are far less important. Properties that do become important are finish, slip resistance, absorption and translucence to mention a few.

Substrates

Determining the limitations and characteristics of the surface that the stone will be installed on is critical. Various substrates will require specific installation methods depending on the stone panel size, setting space and condition of the substrate.

Concrete Slab on Grade

When installing any natural stone product, the most common, stable and desirable construction substrate is a concrete slab. This is the most common substrate found in high rise residential, industrial, institutional and commercial construction sites today. When designing a concrete slab on grade to receive natural stone, close attention must be paid to the compaction of the subsoil. A vapour barrier must be installed beneath the slab to prevent migration of moisture from the soil. The slab must be fully cured (28 days) and free of all curing compounds and latent materials prior to stone installation, if a bonded system is selected. Slabs must not deviate more than 6 mm (3/4 inch) in 3049 mm (10 feet). The slab must have the required control joints cut into the slab within 24 hours of its pour, at designed locations to control cracking. A broom or screed finish is recommended for a bonded system. If the slab has been smooth finished, blast-tracking or scarification is recommended to provide the required texture to allow the setting material to properly bond and key to the substrate.

Suspended (structural) Concrete Slab

When installing any natural stone product, the most common, stable and desirable construction substrate is a concrete slab. This is the most common substrate found above grade in high rise residential, industrial, institutional and commercial construction sites today. When designing with very long spans such as airports, hotels, or convention centres, careful consideration must be paid to total deflection and vibration. Designing to a deflection limit of L/480 may not be enough. (For example, a span of 33 meters (108 feet) designed to L/480 will result in a total deflection of approximately 68 mm (2 5/8 inch). This total deflection may result in too much vibration and too much total deflection for the stone and setting system to perform properly. The concrete slab must be fully cured (28 days) and free of all curing compounds and latent materials prior to stone installation, if a bonded system is selected. Slabs must not deviate more than 6 mm (1/4 inch) in 3049 mm (10 feet). A broom or screed finish is recommended for a bonded system. If the slab has been smooth finished, blast-tracking or scarification is recommended to provide the required texture to allow the setting material to properly bond and key to the substrate.

Conventional Wood Frame Construction

The most common construction method for low rise residential is wood framing. Unfortunately, in many cases the finishes for the floors are not predetermined and often the framing is not designed to meet the requirements for stone installation. The ideal sub-floor to receive stone flooring is 32 mm (1 1/4 inch) thick tight faced multi-ply Douglas Fir exterior grade plywood meeting the requirements of CSA O121 and the floor framing designed to meet a live load deflection limit of at least L/480. This will give the finished floor the stiffness and stability necessary for a quality, carefree and functionally sound stone installation. It is important to ensure that the finished plywood sub-floor is smooth and flat and properly fastened to the framing members below. As a minimum, it is recommended that total load deflection be limited to L/360. The use of tongue and groove plywood should be avoided.

In cases where the sub-floor has not been built for a stone installation, additional strength can be achieved by adding a Cement Backer Unit (CBU) directly over the wood sub-floor. The thickness of the CBU can be part of the required 32 mm (1-1/4 inch) layered thickness.

Expansion/Control Joints

It is important to understand the difference between an expansion joint and a control joint. An expansion joint is a joint designed to allow movement in the structure. A control joint is a saw cut in the slab used to control cracking. By strategically placing control joints in the slab, any cracks due to shrinkage during curing should happen along the control joints. In both cases it is imperative to align the stone expansion or control joints with those in the structure. Never bridge a control joint or an expansion joint with a bonded system.

Cracks

Review the substrate carefully for cracks and determine the origin and reason for the cracking. The cause of the crack will determine the course of action to be taken. If the crack requires a crack suppression material, ensure that they are compatible with the setting material and system that has been or will be specified.

Gauging

The majority of stone products are quarried and extracted in blocks then gang sawed into slabs of a desired thickness. During the gang saw process the thickness of the slabs is tightly controlled. Although fabrication technology allows for tight tolerances, some variations in thickness must be expected. Some stones such as slates are split along their natural cleavage planes into slabs of varying thickness. Some finishes such as split face or thermal often result in additional variations in thickness. The setting method selected must accommodate these variations in thickness. For stones or finishes with larger variation, a mortar bed installation is recommended. For exposed finished edges, it is advisable to gauge the edges to a consistent thickness so variations in thickness are not visible along the finished edge.

Panel Size

Panel size often dictates the setting method required. Larger panels typically require a mortar bed installation. The larger the panel, the more difficult it is to achieve a 90 percent contact. With a mortar bed installation, the panel is Back buttered, set into a fresh dry pack and beaten into place. The mortar bed installation also allows the setter to more easily accommodate variations in the substrate. Smaller panels can typically be installed on thinner setting beds.

Precautions

Natural stone products should never be installed directly over dimensionally unstable substrates such as hardwood floors, linoleum, particleboard, Masonite, chipboard, Luan, or gypsum floor patching compounds.

Translucent

Some stones such as onyx and white marbles can be very translucent. The selection of the setting material can affect the finished colour. It is recommended to use white coloured setting materials when installing translucent products.

Moisture/Absorption

Many stones react adversely with moisture. In these cases, direct contact to a setting system that contains large amounts of moisture is not recommended. Epoxy mortars can be used as an alternate to cementitious setting products. Coating the back of the stone with epoxy several days before installation can help prevent the moisture from penetrating the stone with some materials. If in doubt, a small mock up should be completed ahead of time. Some of the more susceptible stones are red and green coloured and some black marbles.

Deflection

The floor area over which stone is to be applied must be designed to have a total load deflection not greater that L/360 of the span. Allowance should be made for live load and impact as well as all dead load, including weight of stone and setting bed. It is recommended that live load deflection be designed for L/480.

Sealers & Curing Agents

If a sealer and/or curing agent was used on the concrete substrate, it must be completely removed prior to installation of the stone. Removal can be by way of chemical or mechanical means such as sand blasting or blast tracking.

Jointing

Joints can be defined as the space between stone panels and/or the space between stone panels and adjacent finishes. The primary function of a joint is to allow for movements, which may take place in the floor assembly. Thermal contraction/expansion, vibrations, and floor deflection will cause stone panels to chip if they are installed with no joints. Joints will not eliminate the telegraphing of cracking from the substrate to the stone, nor can they accommodate large movements in the substrate. These conditions are addressed with control and or expansion joints along with antifracture membranes. Interior joints typically range from 2 mm (1/16 inch) to 6 mm (1/4 inch). Joints under 6 mm (1/4 inch) are typically filled with unsanded grout.

Surface Preparation

It is essential to inspect the substrate and identify questionable conditions that may cause problems. Measurements must be taken to correct any poor conditions prior to installation. This will prevent future problems and customer call-backs. Damaged concrete surfaces must be repaired prior to installing natural stone products. Failure to do so will inevitably result in cracked or broken stone or grout joints or debonding of the stone.

In the case of an uneven or pitted surface on the concrete sub-floor, applying a floor patching or leveling compound very often is an appropriate corrective action. These products should always be cement based and are applied directly over the concrete sub-floor. Never use water soluble floating or patching compounds that contain gypsum filler. These products will react to the moisture contained within the setting material used to adhere the stone.

Surface cracks in a concrete sub-floor require corrective action prior to installation. Often times cracks are found in renovation or restoration projects. Corrective action often involves the use of a crack isolation membrane. Most of these membrane systems have limitations and should only be used when repairing cracks, no larger than 3 mm (1/8 inch) in width. Crack isolation membranes are designed to isolate the cracked concrete sub-floor from the finished surface of the natural stone. This preventative action will greatly reduce minor movements in the sub-floor from migrating through to the finished surface.

Installation Systems

In order to select the appropriate installation method for interior stone flooring many factors must be taken into consideration. Most significantly, the type, thickness and size of material being installed and the substrate it is being installed on. Several installation methods are available, and each has their specific applications. Regardless of the system selected, industry standard requires a minimum 90% contact between the stone and the setting bed. It is recommended to back butter the stones prior to setting into the bed or mortar system to ensure proper bond. Back buttering is a term used to describe troweling a layer of setting material onto the back of the stone.

MORTAR BED SEPARATED FROM CONCRETE SUBSTRATE (FLOATING FLOOR)

Introduction

This system is comprised of an uncoupling membrane or slip sheet installed over the substrate. The purpose of the slip sheet is to allow slight movements in the substrate to act independently of the mortar bed and the bond to the stone. I

t also prevents the substrate from absorbing moisture from the setting bed which is essential for the bed to cure properly. The mortar bed is set on top of the slip sheet and reinforced with galvanized wire mesh located approximately at the center of the mortar bed. The stone is back buttered and beat in the fresh mortar bed, leveled and allowed to cure.

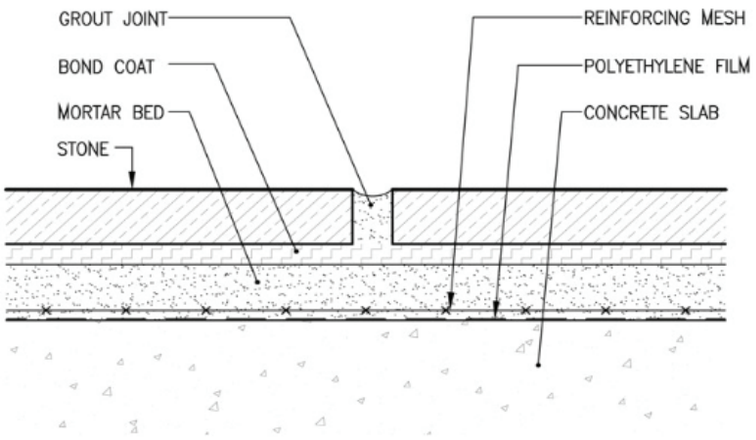
Application

A floating floor system is recommended when dealing with larger panels or where slight movements in the substrate are expected for both residential and commercial applications. A setting space of 38 mm (1-1/2 inch) to 65 mm (2-1/2 inch) in addition to the stones thickness is required for installation. This method can easily accommodate variations in the thickness of the stone and can correct poor levels in the substrate.

The frequency and location of control and expansions joints is critical to the proper performance of this application. Expansion joints must align with the expansion joints of the structure. Control joints must be spaced to accommodate the expected movements in the floating floor assembly.

Substrate

All of the substrates mentioned above are acceptable providing they are designed to the required deflection limitations.



INSTALLATION OVER CONCRETE
(FLOATING FLOOR SYSTEM)

INSTALLATION OVER WOOD FLOOR (FLOATING SYSTEM)

Introduction

This method is mostly used in low-rise construction where wood joists and wood sheathing are normally used. In many cases the floors are not designed to meet the requirements for installation of stone using the medium bed method directly over plywood surfaces due to movement and deflection of the substrate. Therefore, a mortar underbed is used.

This system is comprised of a polyethylene film installed over the substrate. The purpose is to separate the mortar bed from the substrate and to allow slight movement in the substrate to act independently of the mortar bed and the bond to the stone. It also prevents the substrate from absorbing moisture from the mortar bed.

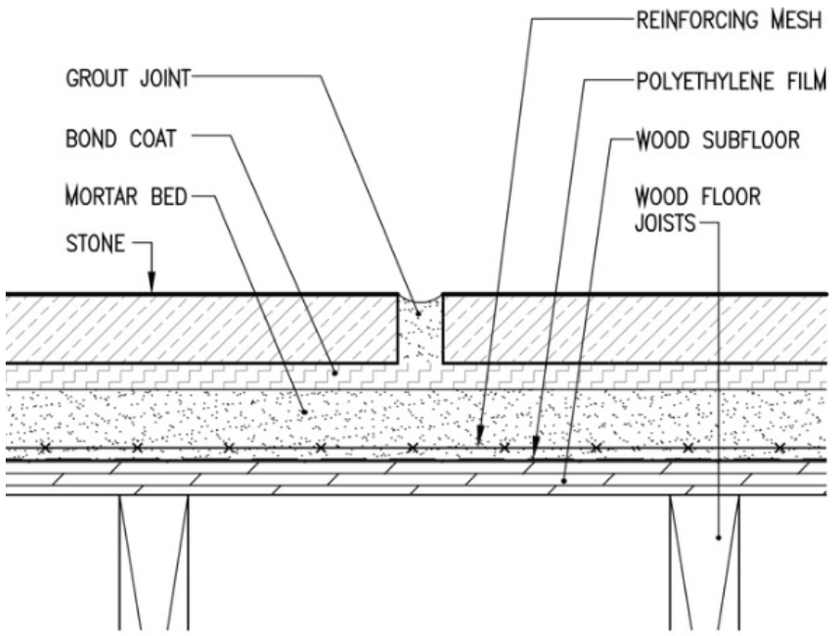
The mortar bed is set on top of the polyethylene film and reinforced with 50 mm (2 inch) x 50 mm (2 inch) galvanized wire mesh located approximately at the centre of the mortar bed. A minimum setting space of 32 mm (1-1/4 inch) is required in addition to the stone thickness. This method can easily accommodate variations in the thickness of the stone and can correct poor levels in the substrate.

Application

Place and screed underbed mix to the required plane. Wipe any residue from back side of slab. Back butter underside and tamp firmly while underbed is still fresh to a level plane. Use sufficient bond coat to ensure a minimum of 90% contact. Contact shall be evenly distributed to give full support of the slab. Allow underbed and bond coat to cure. Force grout into full depth of joint, remove excess grout and clean. Finish tolerance of mortar bed not to deviate more than 3 mm (1/8 inch) in 3 m (10 ft).

Substrate

All of the substrates mentioned above are acceptable providing they are designed to the required deflection limitations.



INSTALLATION OVER WOOD FLOOR
(FLOATING FLOOR SYSTEM)

BONDED MORTAR BED

Introduction

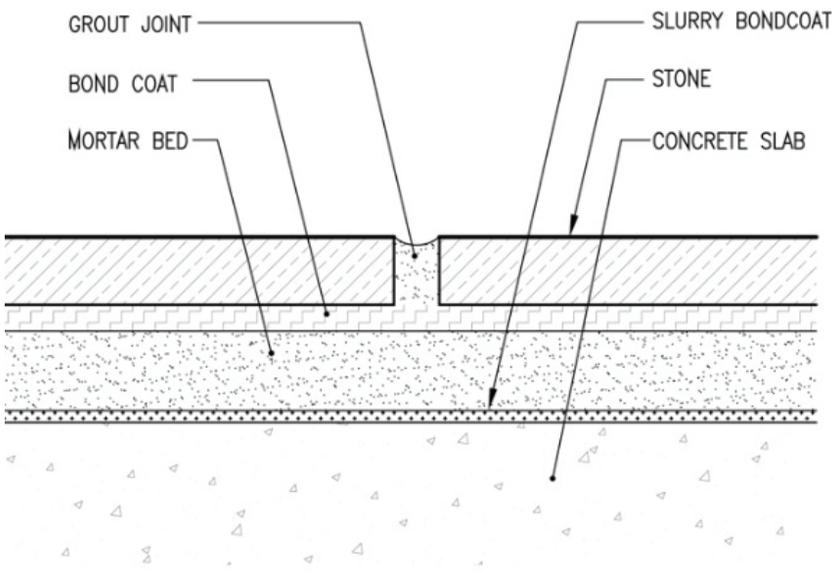
The bonded mortar bed is the most common method of installation for large dimension stone flooring panels. The only difference between this system and the floating floor system is the slip sheet. A bonded mortar bed system is bonded to the substrate with the use of a slurry coat or bond coat. Back buttered stone is then beat into the fresh mortar bed, leveled and allowed to cure.

Application

This system is very suitable when setting larger panels onto very stable substrates. Any flaws or cracks in the substrate not properly addressed may eventually telegraph through to the substrate. A setting space of 38 mm (1-1/2 inch) to 65 mm (2-1/2 inch) in addition to the stone thickness is required for installation. This method can easily accommodate variations in the thickness of the stone can correct poor levels in the substrate. This method is commonly specified in commercial applications over concrete substrates. This is also a very practical system to be used over radiant heat cables/tubes.

Substrate

All of the substrates mentioned above are acceptable providing they are designed to the required deflection limitations.



BONDED MORTAR BED

MEDIUM BED BONDED

Introduction

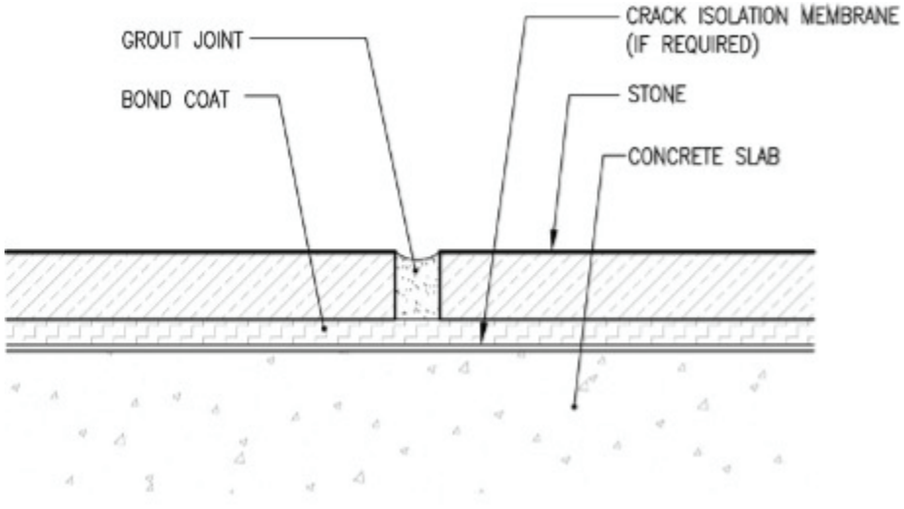
This form of setting system was recently developed to utilize the economical thin-set method with larger dimension stone panels. A medium bed mortar was also the answer for many architects and designers who did not have the setting space for a traditional mortar bed installation for dimension stone. A medium bed ranges from 12 mm (1/2 inch) to 25 mm (1 inch) in thickness. Like thin-sets these products are typically cementitious but have larger sand aggregates which help to elevate the larger stone panels.

Application

This system was designed for dimension stone that typically are larger than 0.23 sq. m (2.5 sq. ft.) and where setting space is restricted to 25 mm (1 inch) or less.

Substrate

All of the substrates mentioned above are acceptable providing they are designed to the required deflection limitations.



MEDIUM BED BONDED

MEDIUM BED OVER BACKER UNIT/BOARD

Introduction

This method is also used in low-rise residential installations where height restrictions do not permit the use of a traditional mortar bed installation for dimension stone, it should only be used if a structurally sound floor can be provided. Dimensional stability is critical to the plywood sub-floor and should be constructed using exterior grade plywood (meeting CSA 0121) and must have a minimum thickness of 16 mm (5/8 inch) and properly fastened to the framing members below.

To provide additional thickness and strength to the floor a backer unit/board is installed. This will give the floor the stiffness and stability necessary for a functional installation. The thickness of the CBU can be part of the required 32 mm (1-1/4 inch) layered thickness.

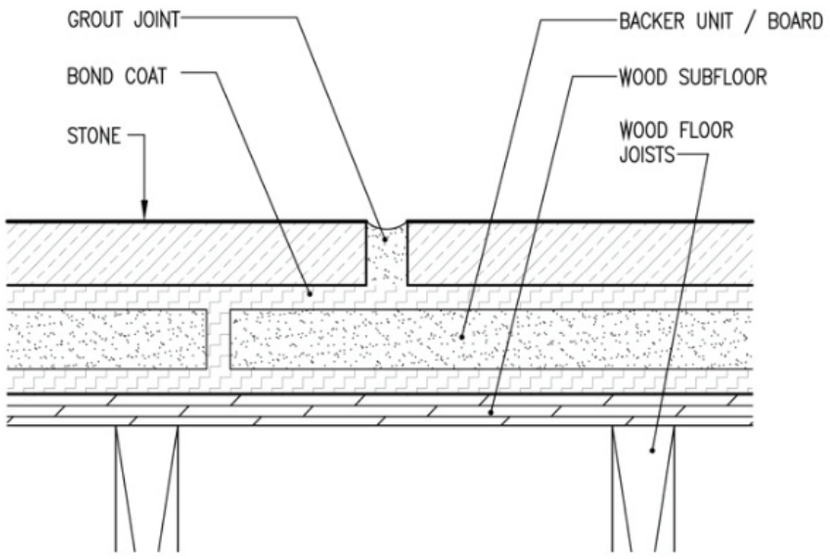
Substrate

Minimum 12 mm (1/2 inch) cementitious backer unit (CBU), coated glass mat backer board, fibre-cement backer board bedded in latex Portland cement mortar gapped 3 mm (1/8 inch). Fasten underlayment to subfloor with 30 mm (1-1/8 inch) galvanized screws placed 150 mm (6 inch) o.c. around perimeter and 200 mm (8 inch) o.c. throughout the body of the panel.

Application

Spread latex-Portland cement bond coat to underlayment using medium bed setting material ranging from a minimum thickness of 12 mm (1/2 inch) to a maximum of 25 mm (1 inch) depending on size and thickness of the stone, skim-coat underside and set before bond coat skins over to a level plane. Use sufficient bond coat to ensure a minimum of 90% contact. Contact shall be evenly distributed to give full support to the slab. Force grout into full depth of joint, remove excess grout and clean.

Finished level tolerance not to exceed 3 mm (1/8 inch) cumulative over 3049 mm (10 feet) linear measurement in any direction. This system is designed for dimension stone slabs 19 mm (3/4 inch) thick to no larger than 0.23 sq. m (2.5 sq. ft.) and where setting space is restricted to 25 mm (1 inch) or less.



MEDIUM BED OVER BACKER UNIT / BOARD

NATURAL STONE INSTALLATION ON INTERIOR/EXTERIOR STAIRS

For the purpose of this manual, stone flooring will be classified as material that is greater than 19 mm (3/4 inch) in thickness for the use in residential and commercial applications. For stone products less than 19 mm (3/4 inch), refer to TTMAC Specification Guide 09 30 00 Tile Installation Manual. When selecting a material for stairs, many factors must be taken into consideration. Slip resistance must be considered and the stone finish must be specified. In many public areas, vision impaired strip warning strips are required at the top of stairs and non slip carborundum strips are required at the edge of each step. Consultation with a TTMAC supplier and/or contractor prior to finalizing stone selection can prove to be very beneficial.

GENERAL INFORMATION

Sampling and Mock-Ups

The stone contractor shall submit samples of all the specified dimension stones to the architect for approval. The sample sizes should be specified by the architect at the time of tender. The number and size of samples should clearly show the colour and shading range that will be acceptable as well as identify extreme veining and/or inclusions. If non slip strips are required it is recommended that samples be submitted for approval. Samples must be unconditionally approved or rejected in their entirety. In some cases architects and contractors will view and select the actual slabs to be used for the project.

The designer or architect may request a mock up for the purpose of viewing and approving the colour and shading range and set the standards for fabrication and installation tolerances. Mock-ups can form part of the completed work.

Shop Drawings

Shop drawings must clearly convey all relevant information to the architect, contractor and installer. Relevant information is to include the necessary plans, sections and details to clearly dimension and detail all the stone and its interface with adjacent materials. The architect and contractor are to ensure that all information on the shop drawings has been interpreted properly and approve the dimension information on the drawings. With the lead times required to fabricate stone, providing dimension approval at an early stage will allow for expeditious material procurement and ordering and in turn ensure material is delivered on schedule. Project specifications should clearly indicate the shop drawing requirements and architects should accept nothing less.

Gauging

The majority of stone products are quarried and extracted in blocks then gang sawed into slabs of a desired thickness. During the gang saw process the thickness of the slabs is tightly controlled. Although fabrication technology allows for tight tolerances, some variations in thickness must be expected. Some finishes such as split face or thermal often result in additional variations in thickness. The setting method selected must accommodate these variations in thickness. For exposed treads, it is advisable to gauge the edges so variations in thickness are not visible along the finished edge.

Availability & Consistency

Each variety of stone has its own particular range of variation. Some variations are quite subtle and others can be extreme. Once familiar with the range, precautions should be taken to ensure sufficient quantities to accommodate design requirements. When approving samples, architects and designers must understand that stone is a natural product and there will be subtle differences between quarries, blocks, and in many some cases from slab to slab.

Detailing

Since each material has its own unique physical characteristics, each material will respond differently to detailing. Finishes and panel size must be considered when selecting a stair material. Some materials, such as some limestones, marbles and slates have limited slab sizes. Some materials cannot be polished while others can be polished and not flamed.

Fabrication

Ensure that the fabricator of choice has sufficient experience in preparing stone for the intended use. If the fabricator is overseas, compensate for the increased lead-time and order additional material for unexpected changes and/or damage. In some cases over sizing panels may help compensate for site conditions.

DESIGN COMPONENTS

Setting Systems

The setting systems for stairs vary depending on the stone material, thickness, setting space, and substrate. The available substrates and setting material combinations for both exterior and interior stair installations are substantial. This manual gives several examples.

Physical Properties - Stone

When designing with stone one must be aware of the physical properties of the stone and its abilities to meet the requirements of the design. The physical requirements for stone used on stairs are quite different than those for cladding or other flooring applications. Properties that do become important are hardness, finish, slip resistance and absorption to mention a few.

Deflection and Vibration

Deflection and vibration are both important factors to consider when designing stairs to receive stone, particularly with steel and wood substrates where the structures are generally lighter than poured concrete. The total combined dead and live load deflection should be limited to L/360 of the span. It is recommended that live load deflection be limited to a maximum of L/480.

Substrates

Determining the limitations and characteristics of the surface that the stone will be installed on is critical. Various substrates will require specific installation methods depending on the stone panel size, setting space and condition of the substrate. Acceptable substrates for interior and exterior applications vary dramatically.

Reinforced Poured Concrete

Use a screed finish for interior/exterior installations using an underbed installation and a fine broom or steel trowel finish if the intention is to set the stone using a thin-set installation. Inspect the concrete surface to ensure it is free of cracks or oily films and curing compounds.

Concrete Filled Steel Pan

As with poured concrete, use a screed finish for installations using an underbed installation and a fine broom or steel trowel finish if the intention is to set the stone using a thin-set installation. Inspect the concrete surface to ensure it is free of cracks or oily films and curing compounds.

Structural Steel

Although not commonly used, there are projects where stone is installed directly onto steel. In these cases, the structure must be rigid enough to prevent vibration. Stairs with high vibration, could result in the stone losing its bond. It is recommended that dowels or a mesh be welded to the steel to ensure proper bond to the steel.

Wood

Stairs constructed of wood and designed to receive stone must be limited to interior use only.

Stone Materials

For interior installations, materials such as marble, granite, limestone, slate, sandstone and agglomerate (quartz based stone) are acceptable. For exterior installations, materials that are resistant to the elements and slip resistant should be considered. The most common materials used are granites with a slip resistant finish such as honed, thermal (flamed), sawn and sand blasted, should be used. Other materials can be used, however suppliers should ensure resistance to the elements and resistance

Underbed Materials

Portland cement must meet CAN/CSA-A5-93 and sand must be clean washed to ASTM C144. A slurry bond coat must be used. Galvanized metal lath must be 1.4Kg/m2, meeting ASTM C144. A cleavage membrane of 0.10 mm (4 mils) polyethylene film is required, meeting CAN/CGSB-51.34. (Many manufacturers have premixed products suitable for these installations. Follow manufacturer's recommendations.

Underbed

One part Portland cement to three parts clean washed sand by volume is required. Use sufficient clean water and mix thoroughly to a low slump to provide workability. (Many manufacturers have premixed products suitable for these installations. Follow manufacturer's recommendations.

Bond Coat

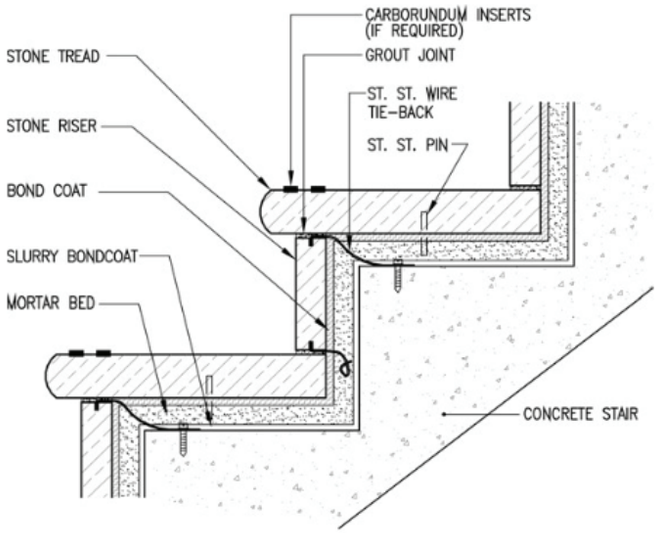
Use Latex Portland cement or two component liquid latex cementitious mortar over a fresh or cured mortar bed for interior or exterior installations. Cure for a minimum of 24 hours. Modified epoxy emulsion mortars or 100% solid epoxy mortar can be used only on interior installations. (Many manufacturers have premixed products suitable for these installations. Follow manufacturer's recommendations.

Grout

For interior installations use Portland cement, latex Portland cement or epoxy grout on a mortar bed cured for a minimum of seven days. For exterior installations use Portland cement or latex Portland cement. (Many manufacturers have premixed products suitable for these installations. Follow manufacturer's recommendations.

Installation onto Concrete over Fresh Underbed (Interior/Exterior)

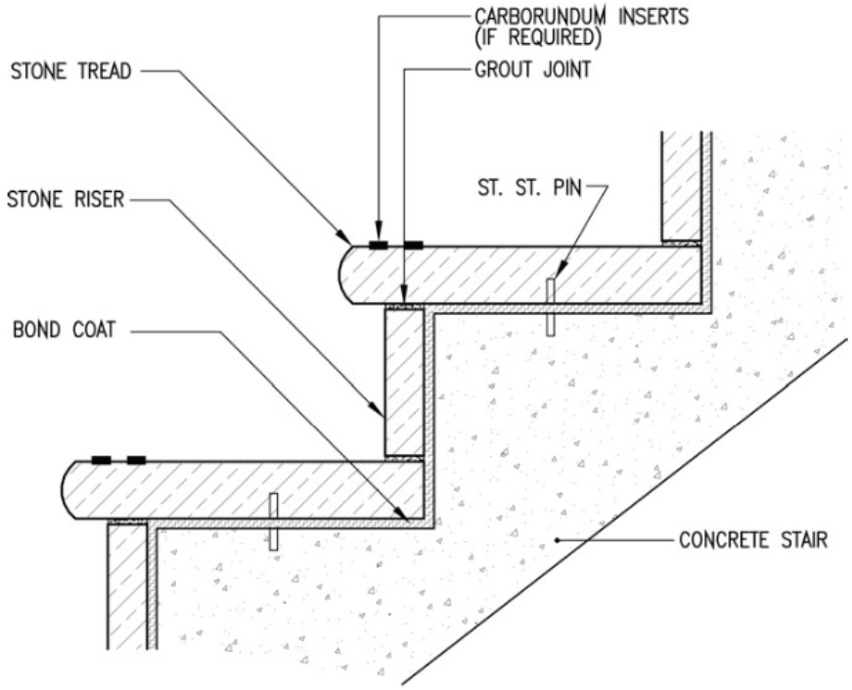
Broom clean concrete steps and risers to remove loose debris and dust, saturate with water and remove any excess water from the treads. Apply a slurry bond coat consisting of water combined with a cement latex additive. Place a screed mix and build up to the required thickness on treads and risers. Prepare a bond coat using a latex Portland cement mortar and use this to back butter the treads and risers. Use sufficient bond coat to ensure a minimum of 90% contact. Place treads and risers into position and beat into place. It is strongly recommended that risers be mechanically fastened with wire to ensure proper bond and adhesion. Set risers and treads straight and true to conform with all detail dimensions. Contact between the substrate, setting bed and stone shall be evenly distributed to ensure full support to the stone. Allow assembly to cure. Follow manufacturer's recommendations. Force grout into full depth of the joint. Remove excess grout and clean.



STONE STAIR ON CONCRETE (MORTAR)

Installation on/to Concrete - Thin-Set Method (Interior/Exterior)

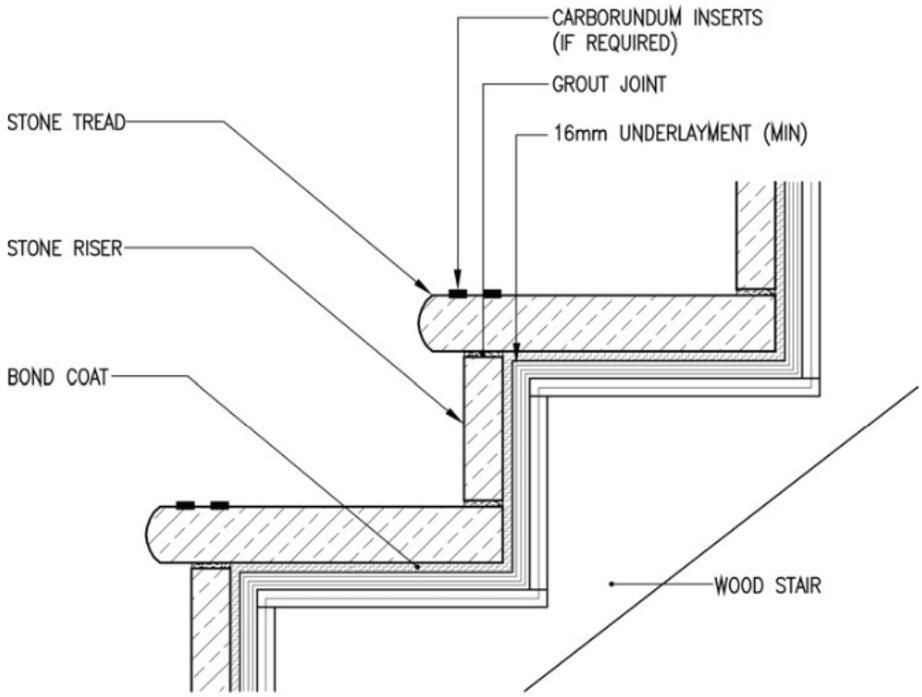
Concrete is required be sound with a steel trowel or fine broom finish, free of cracks, contaminants, curing compounds or laitance. The surface variation of a concrete slab must not exceed 6 mm (1/4 inch) in 3049 mm (10 feet) from the required plane and not more than 2 mm (1/16 inch) in 305 mm (1 inch). A slight leveling coat may be required on a substrate to adjust any irregularities. Allow leveling coat to cure prior to the application of the bond coat and stone. Apply the bond coat directly over the substrate or leveling coat. Back butter treads and risers using a latex Portland cement mortar. Use sufficient bond coat to ensure a minimum of 90% contact. Set and align stone treads and risers straight and true to conform with all detail dimensions. Contact between the substrate, setting bed and stone shall be evenly distributed to provide full support to the stone. Allow the assembly to cure. Follow manufacturer's recommendations. Force grout into full depth of joint, remove excess and clean.



STONE STAIR ON CONCRETE (THINSET)

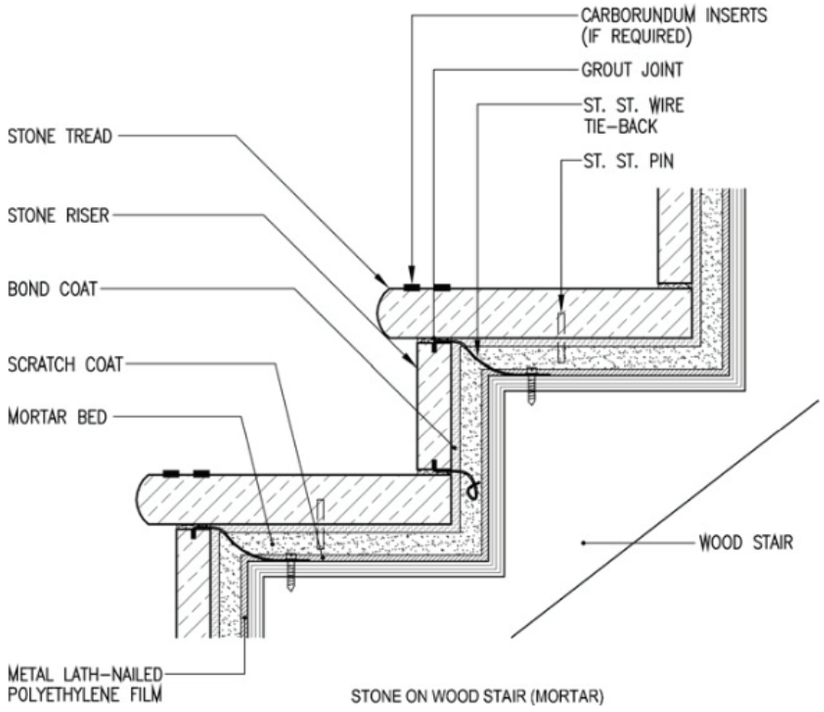
Installation of Stone Directly Bonded to Wood Stairs (Interior Only)

Underlayment is required to be a minimum of 16 mm (5/8 inch) or thicker Douglas Fir exterior grade plywood, glued, nailed or screwed to steps, risers and landing. Minimal thickness of plywood assembly is 32 mm (1-1/4 inch). Surfaces must be swept or vacuumed in order to remove dust. Apply a bond coat of latex Portland cement mortar or 100% epoxy mortar to a wood substrate and to the back of treads and risers. Use sufficient bond coat to ensure a minimum of 90% contact. Set and align stone treads and risers straight and true to conform to detail dimensions. Contact is required to be evenly distributed to give full support to the stone. Allow assembly to cure. Follow manufacturer's recommendations. Force grout into full depth of the joint, remove excess grout and clean. Consult with the manufacturer of epoxy for bonding over wood.



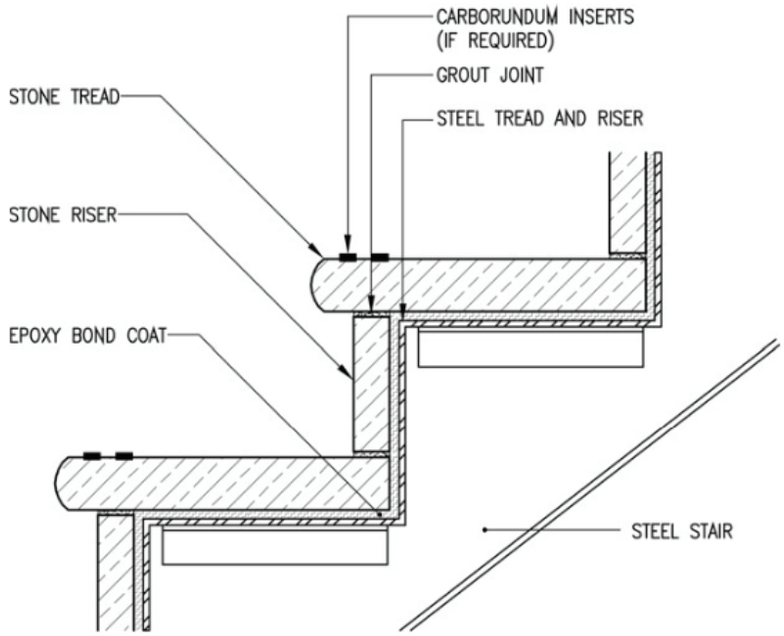
STONE ON WOOD STAIR (THINSET)

Mechanically fasten galvanized metal lath to wood substrate over cleavage membrane. Apply scratch coat to metal lath, apply mortar bed while scratch coat is in a plastic state and build up to the required thickness on treads and risers. Apply bond coat using a latex Portland cement mortar and back butter the treads and risers. Use sufficient bond coat to ensure a minimum of 90% contact. Place treads and risers into position and beat into place. It is strongly recommended that risers be mechanically fastened with wire to ensure proper bond and adhesion. Set risers and treads straight and true to conform with all detail dimensions. Contact between the substrate, setting bed and stone shall be evenly distributed to ensure full support to the stone. Allow assembly to cure before allowing traffic on the stairs. Force grout into full depth of joint. Remove excess grout and clean.



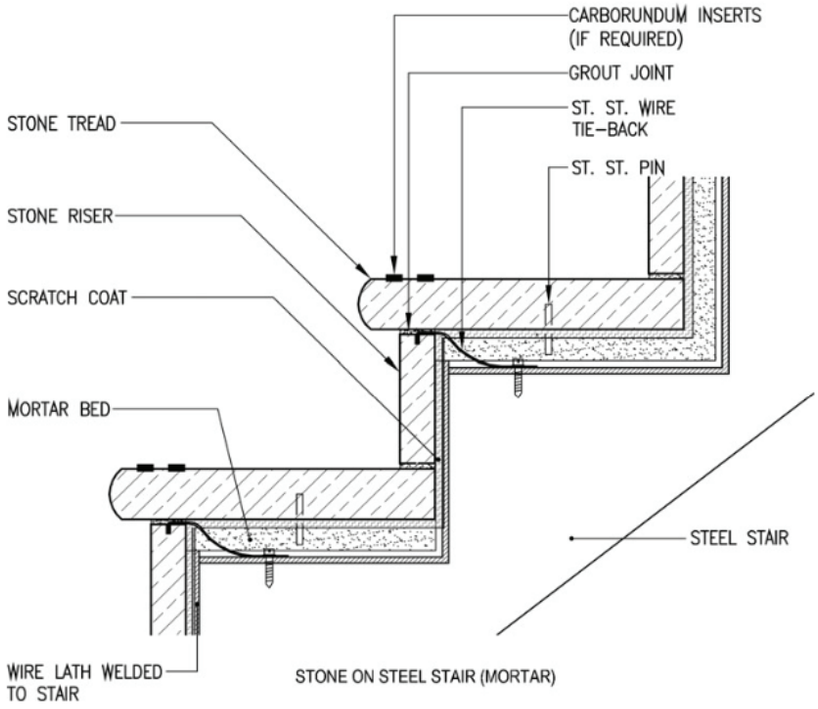
Installation of Stone Directly Bonded to Steel Stairs

Metal substrate must be structurally sound and free of contaminants such as oil or grease. Remove any scaling and rust mechanically by sanding, sandblasting or by other means. Sweep or vacuum surfaces to remove dust. Apply epoxy bond coat material to steel substrate and to back of treads and risers. Use sufficient bond coat to ensure a minimum of 90% contact. Set and align stone treads and risers straight and true to conform with all detail dimensions. Contact is required to be evenly distributed to give full support to the stone. Allow assembly to cure. Follow manufacturer's recommendations. Force grout into full depth of joint, remove excess and clean. Consult with epoxy manufacturer for bonding over steel.



STONE ON STEEL STAIR (THINSET)

Fasten metal lath to treads and risers by tie wire or spot welded by steel stairs fabricator. Omit cleavage membrane. Apply scratch coat to metal lath, apply mortar bed while scratch coat is in a plastic state and build up to the required thickness on treads and risers. Apply bond coat using Portland cement mortar and back butter the treads and risers. Use sufficient bond coat to ensure a minimum of 90% contact. Place treads and risers into position and beat into place. It is strongly recommended that risers be mechanically fastened with wire to ensure proper bond and adhesion. Set risers and treads straight and true to conform with all details dimensions. Contact between the substrate, setting bed and stone shall be evenly distributed to ensure full support to the stone. Allow assembly to sure before allowing traffic on the stairs. Force grout into full depth of joint. Remove excess grout and clean.



Limitations

Wood as a substrate for stairs in exterior installations is not recommended.

For commercial installations subject to heavy foot traffic stone having a minimum abrasive hardness (HA) of 12.0 or more, should be used. Waferboard, particleboard, interior grade plywood should not be used for a substrate or underlayment. Plywood must be completely free of contaminants such as oil, sealers, varnishes, paint or other foreign materials. Organic adhesives are not acceptable for these applications. On exterior stairs, a slight slope on treads is preferred to provide drainage. Stone unit should not have variances greater than 2 mm (1/16 inch) in length, height or width. It is recommended that treads for interior installation have a minimum thickness of 19 mm (3/4 inch), while a minimum thickness of 32 mm (1-1/4 inch) or greater is recommended for exterior installations.

Risers may be 19 mm (3/4 inch), 32 mm (1-1/4 inch) or greater. Risers 19 mm (3/4 inch) or thicker must be anchored with wire or stainless steel strap anchors. Stone with a polished finish should not be used on treads for exterior stair installations. It is recommended that rough, textured, abrasive, flamed, honed and natural cleft finishes be used. Most agglomerate marble should not be used on exterior surfaces unless recommended by the manufacturer. Some types of marble may be suitable for exterior use, although to determine if suitable you must consult with the manufacturer/supplier or perform adequate testing to ensure suitability. Some marbles will disintegrate and/or erode over time particularly when exposed to freeze/thaw cycles. Epoxy setting and grouting is not recommended for exterior installations. Consult with the manufacturer to ensure suitability of their products. Installation of stone over wood stairs is suitable for interior residential and interior light commercial applications only. Some marbles, such as Rosso Levanto, some green marbles, some green slates and some agglomerates have a tendency to warp and curl when installed with a bond coat that contains water. These materials must be installed with a 100% solids epoxy mortar or with a rapid set latex Portland cement mortar.

Other Considerations

Treads and risers may also be applied over cementitious board underlayments. On exterior stairs a slight slope on treads is preferred to provide drainage. Underbed may be installed over a fresh scratch coat. In many applications, particularly in public places, abrasive strips or non slip abrasive filled grooves are required for added safety. These can be fabricated or field installed. Slip resistance for interior and exterior stair treads must be a minimum of 0.6 wet or dry. Follow manufacturer's recommendations (ANSI A118.10-1999) if a waterproof membrane is recommended for exterior applications. Stair risers cannot be less than 125 mm (5 inch) and not more than 180 mm (7 inch) treads and risers must have uniform rise and run in any one flight. Treads must have a run that is not less than 280 mm (11 inch) between successive steps.

Stone treads and risers may also be installed on a fully cured mortar bed following manufacturer's recommendations. When installing denser stones with a low absorbency, such as granite, quartz-based stone or slate, the bond coat should be a latex Portland cement mortar, 100% solids epoxy or modified epoxy emulsion mortar on cured underbed. White Portland cement based setting materials should be used when installing light coloured granite, marble and limestone. Risers 19 mm (3/4 inch) or thicker must be anchored with wire or stainless steel strap anchors. It is always advisable to contact a reputable stone contractor or manufacturer to ensure that the proper setting materials are being used. Even stones within the same categories may have different setting requirements and will react differently to different setting materials.

EXTERIOR STONE - HORIZONTAL

For the purpose of this manual, stone flooring will be classified as material that is greater than 19 mm (3/4 inch) in thickness for use in residential and commercial applications. Stone products less than 19 mm (3/4 inch) in thickness, are addressed in the TTMAC Specification Guide 09 30 00 Tile Installation Manual.

Granite is the most readily used paving material; however, other materials can be used in the appropriate finishes and thickness to provide excellent performance in exterior paving. When selecting an exterior paving material, many factors must be carefully examined and taken into consideration. These factors have been noted and assembled in Appendix A which provides a quick reference guide in aiding in the selection of stone for exterior paving. In some cases stones with lower flexural strength, modulus of rupture and higher absorption can be used in an exterior paving application, depending on the specified thickness, panel size, method of installation and climate.

Consultation with a TTMAC supplier and/or contractor prior to finalizing stone selection may prove to be very beneficial.

General Information

Sampling and Mock-Ups

The stone contractor shall submit samples of all the specified dimension stones to the architect for approval. Sample sizes should be specified by the architect at the time of tender. The number and size of samples should clearly show the colour and shading range that will be acceptable, as well as identify extreme veining and/or inclusions. Samples must be unconditionally approved or rejected in their entirety. In some cases architects and contractors will view and select the actual slabs to be used for the project.

The designer or architect may request a mock up for the purpose of viewing and approving the colour and shading range and to set the standards for fabrication and installation tolerances. Mock-ups may form part of the completed work.

Shop Drawings

Shop drawings must clearly convey all relevant information to the architect, contractor and installer. Relevant information is to include the necessary plans, sections and details to clearly identify dimension and detail all the stone and its interface with adjacent materials. The architect and contractor are to ensure that all information on the shop drawings have been interpreted properly and approve the dimension information on the drawings. With the lead times required to fabricate stone, providing dimension approval at an early stage will allow for expeditious material procurement and ordering and in turn ensure material is delivered on schedule. Project specifications should clearly indicate the shop drawing requirements. Architects should accept nothing less.

Availability & Consistency

Each variety of stone has its own particular range of variation. Some are quite subtle and others can be extreme. Once familiar with the range, precautions should be taken to ensure sufficient quantities to accommodate design requirements. When approving samples, architects and designers must understand that stone is a natural product and there will be subtle differences between quarries, blocks, and in many some cases from slab to slab. To help achieve a more consistent finished surface, panels could be blended by selecting panels from different crates. This way pieces will not be grouped and installed in the order they were fabricated. This blending could also be done after the slab fabrication, before crating. Some projects will require certain ranges to be installed on specific elevations or areas. In this case it will require the owner and architect to review the panels dry laid in the fabrication plant as they would appear on the floor or wall and make any changes needed prior to crating and installation. The techniques mentioned above should be specified at the time of tender due to the additional time and labour required. Even after ensuring that a stone is available from the selected quarry at the quantities required, proximity to a suitable fabrication facility must be noted as this may affect the schedule and quality control of the project. Planned future phases of same project should be considered at the time of initial selection to ensure continuity.

Detailing

As each material has its own unique physical characteristics, each material will respond differently to detailing. Finishes and panel size must be considered when selecting material. Materials suitable for interior flooring may not be for exterior paving.

Fabrication

Ensure that the fabricator of choice has sufficient experience in preparing stone for the intended use. If the fabricator is overseas, compensate for the increased lead-time and order additional material for unexpected changes and/or damage. In some cases over sizing panels may help compensate for site conditions.

DESIGN COMPONENTS

Setting Systems

The setting systems for exterior horizontal stone applications vary widely depending on the stone material, the setting space, the setting material selected and the substrate. As with interior installations, available substrates, setting material combinations and weather exposure offer several alternatives to the system selected.

The designer or architect may request a mock up for the purpose of viewing and approving the colour and shading range and to set the standards for fabrication and installation tolerances. Mock-ups may form part of the completed work.

Physical Properties - Stone

When designing with stone one must be aware of the physical properties of the stone and it's abilities to meet the requirements of the design. The physical requirements for stone in horizontal exterior applications are quite different than those for interior. Properties such as flexural strength, absorption, hardness and freeze thaw become far more relevant in the design.

Substrates

Determining the limitations and condition of the surface that the stone will be installed on is critical. Various substrates will require specific installation methods depending on the stone panel size, setting space and condition of the substrate.

Concrete Slab on grade

This is a very common, stable and desirable substrate for the installation of stone, when constructed properly. This is commonly found in high rise residential, industrial, institutional and commercial construction. When designing a concrete slab on grade to receive natural stone, close attention must be paid to the compaction of the subsoil. A vapour barrier must be installed beneath the slab to prevent migration of moisture from the soil. The slab must be fully cured and free of all curing compounds and latent materials prior to stone installation, if a bonded system is selected. Slabs must not deviate more than 6 mm (1/4 inch) in 3049 mm (10 -ft). The slab must have the required control joints cut into the slab with 24 hours of its pour, at designed locations to control cracking. A broom finish is recommended for a bonded system. If the slab has been smooth finished, blast-tracking or scarification is recommended to provide the required texture to allow the setting material to properly bond and key to the substrate.

Suspended (structural) Concrete Slab

This is a very common, stable and desirable substrate for the installation of stone. This is the most common substrate found above grade in high rise residential and industrial commercial construction sites today. When designing with very long spans such as airports, hotels, or convention centers, careful consideration must be paid to total deflection and vibration. Designing to a deflection limit of L/480 may not be enough. (For example, a span of 33 metres (108-ft) designed to L/480 will result in a total deflection of approximately 68 mm (2-5/8 inch)) This total deflection may result in too much vibration and too much total movement for the stone and setting system to perform properly. The concrete slab must be fully cured (28 days) and free of all curing compounds and latent materials prior to stone installation, if a bonded system is selected. Slabs must not deviate more than 6 mm (1/4 inch) in 3049 mm (10-ft). A broom finish is recommended for a bonded system. If the slab has been smooth finished, blast-tracking or scarification is recommended to provide the required texture to allow the setting material to properly bond and key to the substrate.

Conventional Wood Frame Construction

This substrate is not the most desirable substrate, however if designed properly can work. This is very common in low rise residential, particularly on terraces and balconies. The ideal sub-floor to receive stone flooring is 32 mm (1-1/4 inch) thick tight faced multiply exterior grade plywood meeting the requirements of CSA-0121 and the floor framing designed to meet a live load deflection limit of at least L/480. This will give the finished floor the stiffness and stability necessary for a quality, carefree and functionally stone installation. It is important to ensure that the finished plywood sub-floor is smooth and flat and properly fastened to the framing members below. As a minimum, it is recommended limiting the total load deflection to L/360. The use of tongue and groove plywood should be avoided. The plywood would then receive a water proofing membrane and the stone would be installed using a floating floor system.

The designer or architect may request a mock up for the purpose of viewing and approving the colour and shading range and to set the standards for fabrication and installation tolerances. Mock-ups may form part of the completed work.

Expansion/Control Joints

It is important to understand the difference between an expansion joint and a control joint. An expansion joint is a joint designed to allow movement in the structure. A control joint is a saw cut in the slab used to control cracking. By strategically placing control joints in the slab, any cracks due to shrinkage during curing should happen along the control joints. In both cases it is imperative to align the stone expansion or control joints with those in the structure. Never bridge a control joint or an expansion joint with a bonded system

Cracks

Review the substrate carefully for cracks and determine the origin and reason for the cracking. The cause of the crack will determine the course of action to be taken. If the cracks are substantial enough that a crack suppression membrane is required, ensure that it is compatible with the setting material and system that has been or will be specified.

Gauging

The majority of stone products are quarried and extracted in blocks then gang sawed into slabs of a desired thickness. During the gang saw process the thickness of the slabs is tightly controlled. Although fabrication technology allows for tight tolerances, some variations in thickness must be expected. Some stones such as slates are split along their natural cleavage planes into slabs of varying thickness. Some finishes such as split face or thermal often result in additional variations in thickness. The setting method selected must accommodate these variations in thickness. For stones or finishes with larger variation, a mortar bed installation is recommended. For exposed finished edges, it is advisable to gauge the edges to a consistent thickness so variations in thickness are not visible along the finished edge.

Panel Size

Panel size often dictates the setting method required. Larger panels typically require a mortar bed installation. The larger the panel, the more difficult it is to achieve bonding over 90 percent of the panel area. With a mortar bed installation, the panel is set into an underbed and beat into place. The mortar bed installation also allows the setter to more easily accommodate variations in the substrate. Smaller panels can typically be installed on thinner setting beds.

Moisture/Absorption

Many stones react adversely to moisture. In these cases, direct contact to a setting system containing large amounts of moisture is not recommended. Red and green coloured stone and some black marbles are more susceptible to moisture. Absorption is defined as the percentage of water by weight, absorbed into a stone. This is easily measured with ASTM C97 and can be an initial indicator of the stones suitability for use in exterior paving. That is not to say that stones with relatively higher absorption cannot be used.

Deflection

The structure of a building intended to receive stone must be designed to have a total load deflection not greater that L/360 of the span. Allowance should be made for live load and impact as well as all dead load, including weight of stone and setting bed. It is recommended that live load deflection be designed for L/480.

The designer or architect may request a mock up for the purpose of viewing and approving the colour and shading range and to set the standards for fabrication and installation tolerances. Mock-ups may form part of the completed work.

Coefficient of Friction (COF)

The coefficient of friction is a measurement of the stone's slip resistance. ASTM C1028 is a quantitative measure of the slip resistance of a stones surface, both wet and dry. There are no laws or specific code requirements governing the minimum coefficient of friction however the Occupational Health and Safety Association (OSHA) and other industry guidelines have set 0.50 COF as a floor considered to be slip resistant. Ramps and stairs may require higher coefficients of friction. The American with Disabilities Act (ADA) conducted tests and determined that disabled persons require floors with higher coefficient of friction. They recommend 0.60 for floors and 0.80 ramps.

Sealers & Curing Agents

If a sealer and/or curing agent was used on the concrete substrate, it must be completely removed prior to installation of the stone. Removal may be by way of chemical or mechanical means such as sandblasting, scarifying, or other abrasive surface preparation.

Hardness (Ha) or Abrasion Resistance

ASTM C241 is used to measure the stones Abrasive hardness. The required abrasive resistance of a stone is dependent on the expected floor traffic and may vary from light residential to heavy commercial. The recommended hardness values are:

- Light Traffic – residential where there is light traffic and shoes are not likely to be worn; abrasive hardness of 6 minimum.

- Moderate Traffic – Small commercial or residential were heavy traffic is not likely; abrasive hardness of 7 to 10.

- Heavy Traffic – Areas such shopping malls, banks, lobbies, etc. were the gathering of people is expected; abrasive hardness of 12 as a minimum.

Jointing

Joints can be defined as the space between stone panels and/or the space between stone panels and adjacent finishes. The primary function of a joint is to allow for movement, which may take place in the floor assembly. Thermal contraction/expansion, vibrations, and floor deflection will cause stone panels to chip if they are installed without joints. Joints will not eliminate the telegraphing of cracking from the substrate to the stone, nor can they accommodate large movements in the substrate. These conditions are addressed with control and or expansion joints along with anti-fracture membranes. Exterior joints typically range from 6 mm (1/4 inch) to 12 mm (1/2 inch). Joints under 6 mm (1/4 inch) are not recommended for exterior paving and may be left open or filled with mortar/grout or sealant.

Drainage

The type of drainage designed, must be considered when selecting the type of installation system, and may be designed at the surface of the stone or at the substrate. It is essential to provide adequate slope in both the surface of the stone and the substrate.

Waterproofing

There are several types of waterproofing materials on the market. Some are compatible with various setting products and others are not. Confirm the type of waterproofing that is specified and select your system to ensure compatibility. It is recommended that you contact the manufacturer of the components to ensure this compatibility.

Coefficient of Friction (COF)

The designer or architect may request a mock up for the purpose of viewing and approving the colour and shading range and to set the standards for fabrication and installation tolerances. Mock-ups may form part of the completed work.

Installation Systems

In order to select the appropriate installation method for exterior stone flooring many factors must be taken into consideration. Some of the most significant are; stone type, thickness, panel size, substrate and drainage. Several installation methods are available and each has their specific applications.

Sand Bed

The principle of a sand bed installation is to allow water to drain through the sand into the ground below. Stone pavers are set closely together to create an interlocking system to restrict the movement of individual stones when subjected to live or dead loads. Filter cloths may be installed on top of the substrate as a protective system to prevent the loss of aggregate.

Application

This system may be used in most exterior stone paving installations with vehicular and pedestrian traffic. Small panels set with this system have a tendency to move while large panels may be prone to breaking. In areas were vehicular traffic is expected careful attention must be paid to the stones flexural strength, panel size and thickness. This is a very economical proven system.

Substrate

All of the substrates mentioned in this section are acceptable provided they are designed to the required deflection limitations.

MORTAR BED SEPARATED FROM SUBSTRATE (FLOATING FLOOR)

This system is often used when installing stone over a waterproofing membrane. The mortar bed is set on top of the membrane and reinforced with galvanized wire mesh located approximately at the center of the mortar bed. The stone is back buttered and beat into the fresh mortar bed, leveled and allowed to cure.

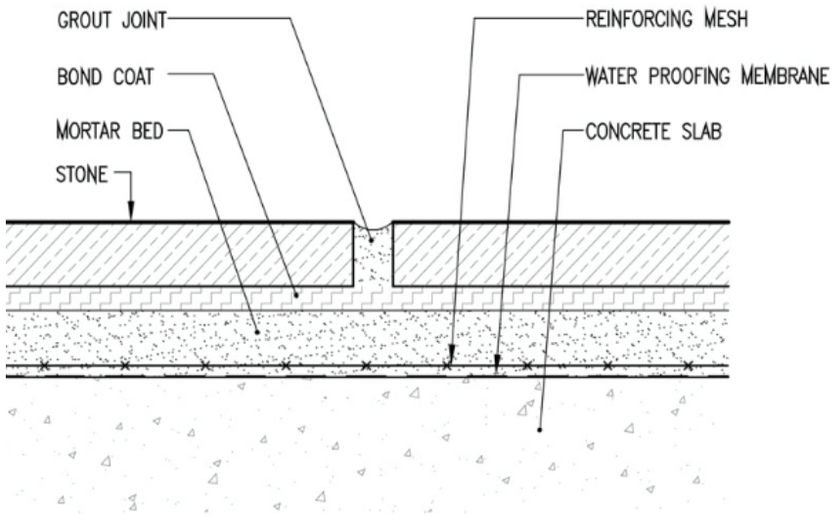
Application

This system is recommended when dealing with larger panels and where heavy traffic and slight movements of substrate are expected and may be used in both residential and commercial applications. A setting space of 38 mm (1-1/2 inch) to 65 mm (2-1/2 inch) in addition to the stones thickness is required for this installation. This method can easily accommodate variations in the thickness of the stone and may correct poor levels in the substrate.

The frequency and location of control and expansions joints is critical to ensure proper performance of this application. Expansion joints must align with the expansion joints of the structure. Control joints must be spaced to accommodate the expected movements in the floating floor assembly.

Substrate

All of the substrates mentioned in this section are acceptable provided they are designed to the required deflection limitations.



INSTALLATION OVER CONCRETE

Bonded Mortar Bed

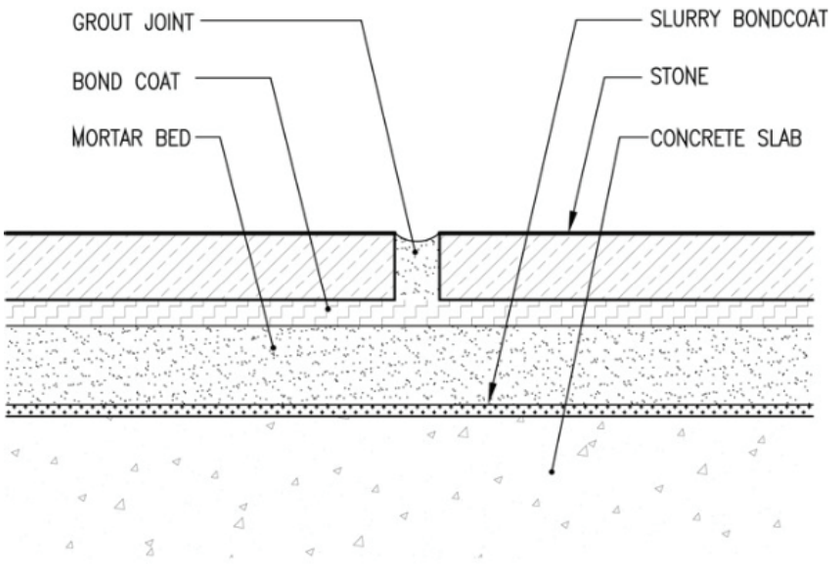
A bonded mortar bed is the most common method of installation for large dimension stone flooring panels. The only difference between this system and the floating floor system is the slip sheet. A bonded mortar bed system is bonded to the substrate with the use of a slurry coat or bond coat. Back buttered stone is then beat into the fresh mortar bed, leveled and allowed to cure. This system requires water to drain along the stones surface. Any moisture penetrating into the under-bed must be designed to drain and not pond. It is essential to have the substrate built with adequate drainage.

Application

This system allows large panels to be set at a smaller thickness than on a sand bed because the setting bed offers better compressive strength. Any flaws or cracks in the substrate not properly addressed may eventually telegraph through. A setting space of 38 mm (1-1/2 inch) to 65 mm (2 1/2 inch) in addition to the stone thickness is required for installation. This method can easily accommodate variations in the thickness of the stone can correct poor levels in the substrate. This method is commonly specified in commercial applications over concrete substrates. This is also a very practical system to be used over radiant heat cables/tubes.

Substrate

All of the substrates mentioned in this section are acceptable provided they are designed to the required deflection limitations.



BONDED MORTAR BED

Pedestal Supported or Corner Supported Method

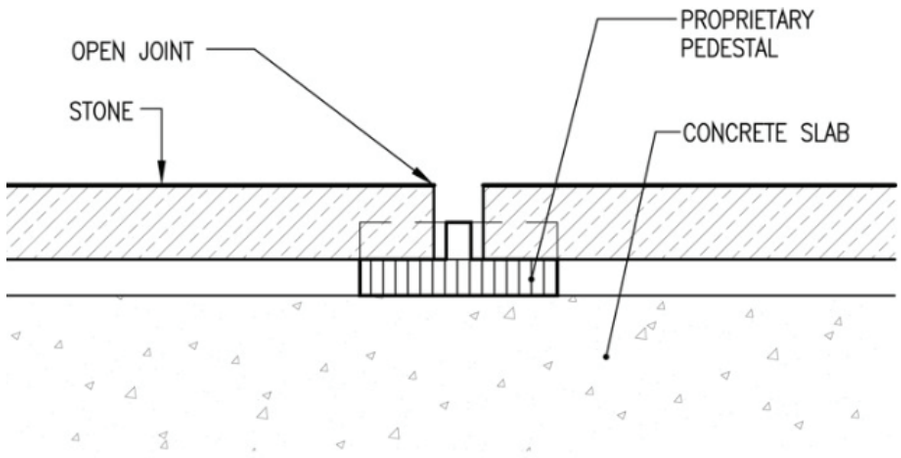
This form of setting system was developed for stone installations where drainage is solely at the surface of the substrate. Stone slabs are supported at the corners of the slab by plastic setting pads, stone setting pads or mortar spots. Joints are left open and water is allowed to flow to the substrate where drainage is provided. The stone must be capable of spanning from the corners to support the design loads. Panel size and stone properties will dictate the stone thickness required.

Application

This method is very often used on roofs or terraces. An advantage of this system is that the stones can easily be removed and reset if required without any damage.

Substrate

Substrate for this system is most often a concrete slab. Other substrates are acceptable, provided they are capable of supporting the stone at the corners. With this system, deflections in the structure have little affect on the performance of the stone.



INSTALLATION OVER CONCRETE
(ON PEDESTALS)

STONE COUNTERTOPS

Natural stone is becoming increasingly more common for use as countertops and vanities. Many natural stones are very resistant to stains, can withstand temperature extremes, are resistant to scratches and require very little maintenance to preserve their natural beauty. Stone is environmentally friendly and offers endless design possibilities. The endless combinations of colour, shades, texture, and veining also adds to the beauty and uniqueness of natural stone. Natural stone will add value and elegance to any application.

General Information

Sampling and Mock-Ups

The stone contractor shall submit samples of all the specified dimension stones to the architect for approval. Sample sizes should be specified by the architect at the time of tender. The number and size of samples should clearly show the acceptable colour and shading range, as well as identify extreme veining and/or inclusions. It is common for architects, designers and homeowners to view and select the actual material to be used for the project.

A mock up for the purpose of viewing and approving the colour and shading range and to set the standards for fabrication and installation tolerances may be required, however mock-ups are generally not provided for countertops particularly when the slabs are selected.

Shop Drawings / Templates

Shop drawings for countertops are most often provided to convey all relevant information to the architect, contractor and installer. This information includes material type and finish, edge details, necessary cut outs, holes or other special conditions and any interface with adjacent materials. The architect/designer/owner/contractor is to ensure that all information on the shop drawings has been interpreted properly and meets the design intent.

All counter-top overhangs should individually address the type of cabinetry, drawer pulls and handles. The overhang should not impede the ability to open and close cabinet doors and drawers. Typically the overhang should extend out from the cabinetry to be flush with the outer edge of the handles and drawer pulls. Flush installations to the edge of the kitchen cabinetry are not recommended.

It is very common to field verify all dimensions and make templates of the finished countertop shape. Templates must either include material type, sink location, sink type, nosing type, backsplash location, overhangs, and if possible gable locations or accompany the template with a drawing providing all the required information. Tops can be produced from architectural or design drawings, provided all parties are aware of their responsibilities to ensure the tops will fit on site. The owner, architect and/or general contractor must guarantee all dimensions and details for this process to work. All drywall, millwork, appliance cutouts, etc. must all adhere to their respective dimensions and details.

Availability & Consistency

Each variety of stone has its own particular range of variation. Some variations are quite subtle and others can be extreme. This is what makes natural stone so attractive to designers/ architects and owners. When reviewing samples, architects and designers must understand that stone is a natural product and there will be subtle differences between quarries, blocks, and in many some cases from slab to slab. It is for this reason that selecting the actual slab is the safest way to ensure consistency in the material intended to be used.

Detailing

Each material has its own unique physical characteristics and will respond differently to detailing. Finishes, material type, cutouts, joint locations and panel size must all be considered in the detailing.

Fabrication

The fabrication requirements and process for countertops differs quite substantially from flooring or cladding. Slabs must be carefully reviewed for any flaws or defects to ensure a consistent finish. The dimensions and/or templates should be laid out onto the slabs such that any grain direction and veining all run in the same direction. (Up and down, across, or diagonal). If possible, all strips for laminating and small returns and back splashes should be cut adjacent to the material they are being laminated to or abutting. This will ensure a harmonious transition between planes. Any epoxies used for lamination should match the stone colour. All built up edges should be ground smooth prior to laminating to ensure a tight joint no greater than 1 mm (1/32 inch). All joints should be dry laid and fitted to ensure that all edges are consistent, both in finish and profile. It is advisable to obtain sink templates and preferably the actual sink for cutouts, particularly with under mount sinks.

DESIGN COMPONENTS

Physical Properties - Stone

When selecting a stone for a countertop you must be aware of the physical characteristics of each stone. Some of the most relevant for countertops are hardness, resistance to acid, absorption and abrasion resistance. One must also be aware of the physical properties of the stone and its ability to meet anticipated service requirements.

Granite, because of its hardness and resistance to acid is the most commonly used countertop material.

Marble and Limestone are very prone to damage from acids such as vinegar, wine, orange juice and other acidic foods or drinks.

Slate, soapstone, sandstone and other natural stones must be reviewed to ensure their suitability for the application.

Substrates

The substrate for stone countertops is most often wood millwork and in some instances metal framing. In both cases it is preferable to have a continuous wood substrate providing full support to adhere to. 19 mm (3/4 inch) plywood with gables or steel frames spaced no more than 915 mm (3 feet) is recommended for 19 mm (3/4 inch) or 30 mm (1-3/16 inch) thick material. All overhangs greater than 200 mm (8 inch) must be reviewed to confirm if support is required. Substrate must be set true and level.

Joints

Stone to stone joints should be made as tight as possible (1.5 mm (1/16 inch) maximum) and epoxied. Stone to cabinetry or other materials should be 3 mm (1/8 inch) and caulked. Joint locations should be carefully located to ensure they are properly supported near gables and a minimum of 100 mm (4 inch) from any cut outs.

Sinks, Faucets, and Other Cutouts

Ensure the sink fits within the clear opening provided in the gables. Ensure that all facets and fixtures are laid out prior to fabrication to ensure adequate clearance from millwork, backsplash and sink flange. Ensure that a minimum distance of 100 mm (4 inch) is left in the front and side of any sink cutouts. Sinks are to be installed by the plumber. Review sink and tap requirements to ensure that any special notches, recessed, or fastening anchors are provided.

Absorption

Most countertops such as kitchen or bathroom tops will frequently be in contact with moisture.

Exceptions may be commercial reception desks and boardroom tables. ASTM C97 tests for absorption (which is the percentage of moisture absorbed by the stone by weight) should be performed to determine suitability of the stone for its intended use. Water is the most prevalent form of moisture that will be in contact with the countertop. It is recommended that a sealer be applied to countertops and they be reapplied as recommended by the manufacturer (typically once a year).

Strength

Countertops are not generally exposed to the same forces as exterior cladding and flooring, however, people have been known to stand on top of counters to change light bulbs or to reach a top shelf. It is for this reason that the stones strength be known and appropriate support be provided. With most cabinets, the support provided by way of gables very often will be adequate for most stone 2cm (3/4 inch) thick or greater. Flexural strength becomes more significant when determining maximum unsupported overhangs and determining whether a small strip requires reinforcement or not. Flexural strength also becomes a factor if the stone is required to sit on gable supports only, without plywood support.

Abrasion Resistance/Hardness

Several tests have been developed to measure a stone hardness and resistance to wear and abrasion. ASTM C1378 measures scratch resistance based on the MOH's Scratch Hardness test. The higher the value, the more resistance the stone is to abrasion. This is a critical factor in commercial reception desk and residential countertops. Granite and quartz surfaces typically provide greater abrasion resistance than other natural stones.

Finishes

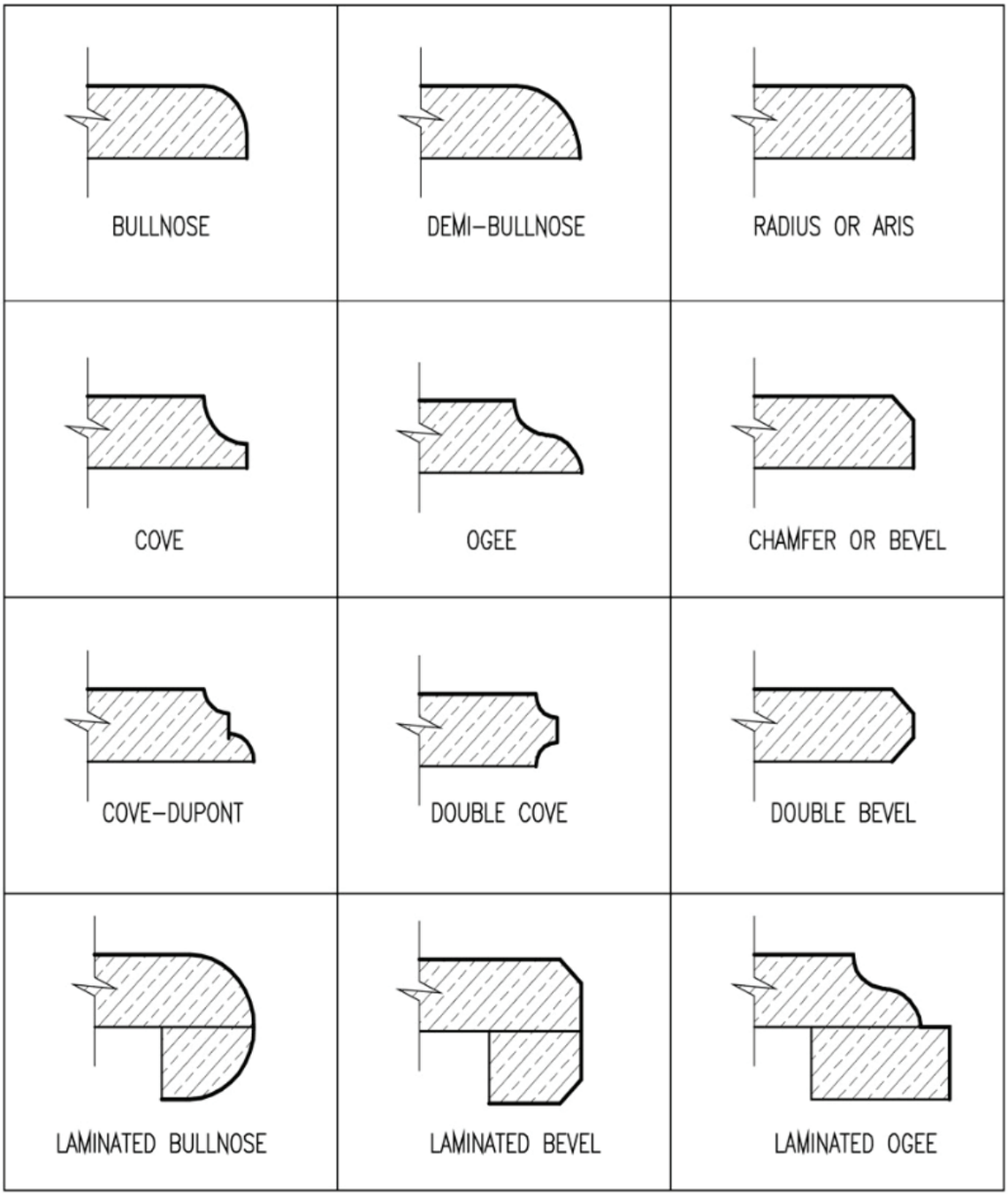
Countertops are most often fabricated with a polished or honed finish. A polished finish generally closes more of the surface offering better resistance to moisture. Honed surfaces have become more popular but typically have a higher absorption rate than polished finished stones. Some manufacturing lines coat the surface with epoxy allowing the epoxy to fill any pits or micro-fissures prior to finishing. This helps in making the material very resistant to moisture and far less reliant on sealers.

Installation Systems and Procedure

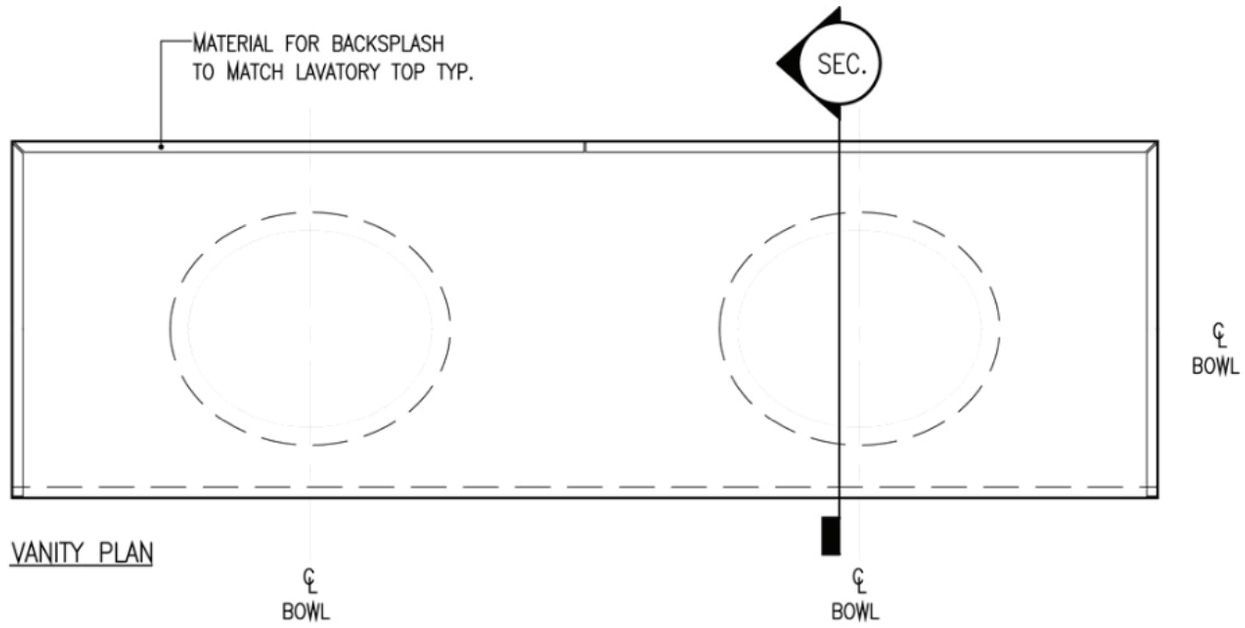
The installation systems available are quite limited for countertops. Tops are typically installed over a plywood substrate. Tops can be installed over gables only, but this installation system should be reviewed by the fabricator and installer prior to fabrication to ensure the material is suitable for spans required. Non-staining silicone caulking can be used as an adhesive between the wood and stone.

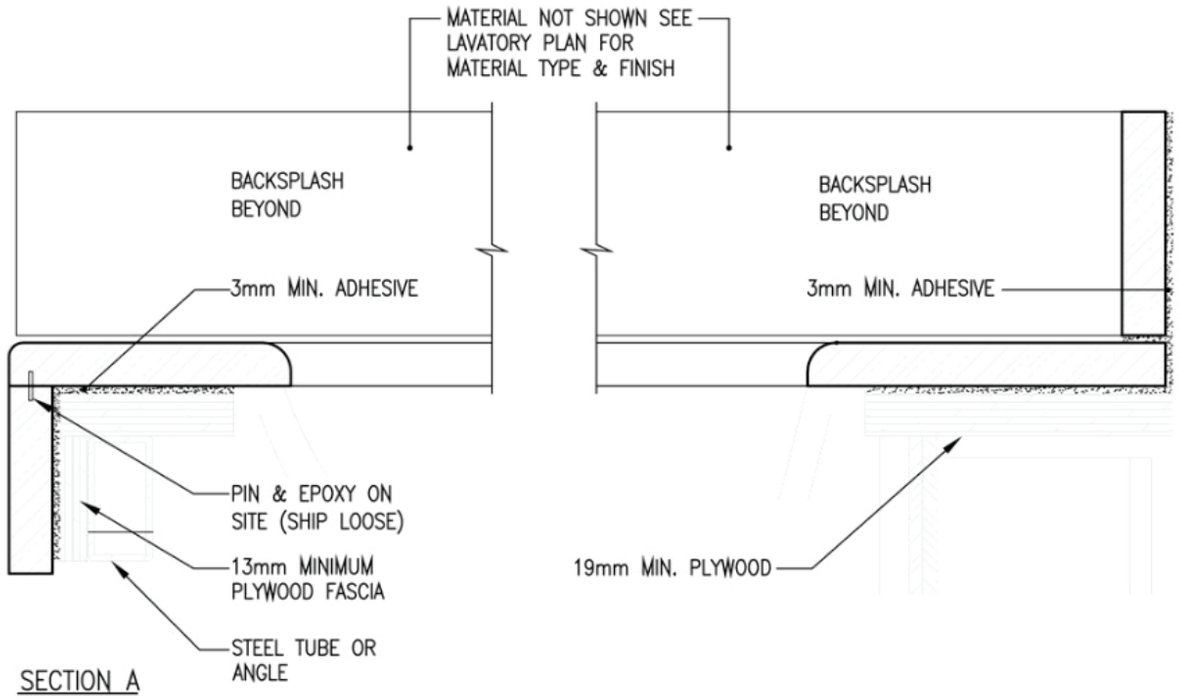
A typical installation procedure is to dry fit the pieces to ensure proper fit and levelness. Liberally apply caulking to the substrate and set the pieces into place. All surface joints should be no greater than 1.5 mm (1/16 inch) and must be filled with matching epoxy. Caulk all joints to adjacent finishes. Clean and apply a coat of sealer if requested by the owner in accordance with manufacturers' instructions.

Common Edge Profiles

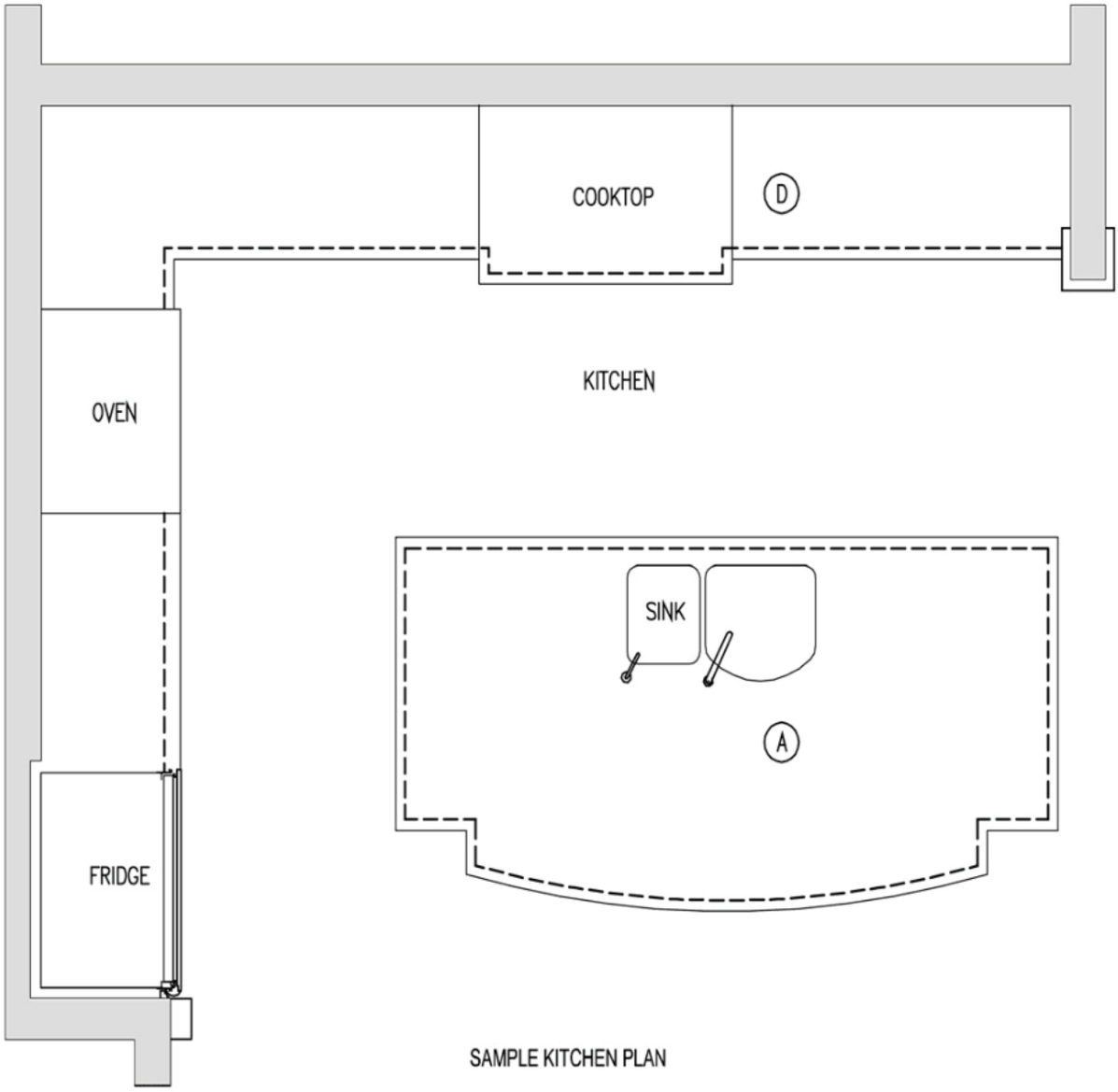


SOME COMMON
EDGE PROFILES

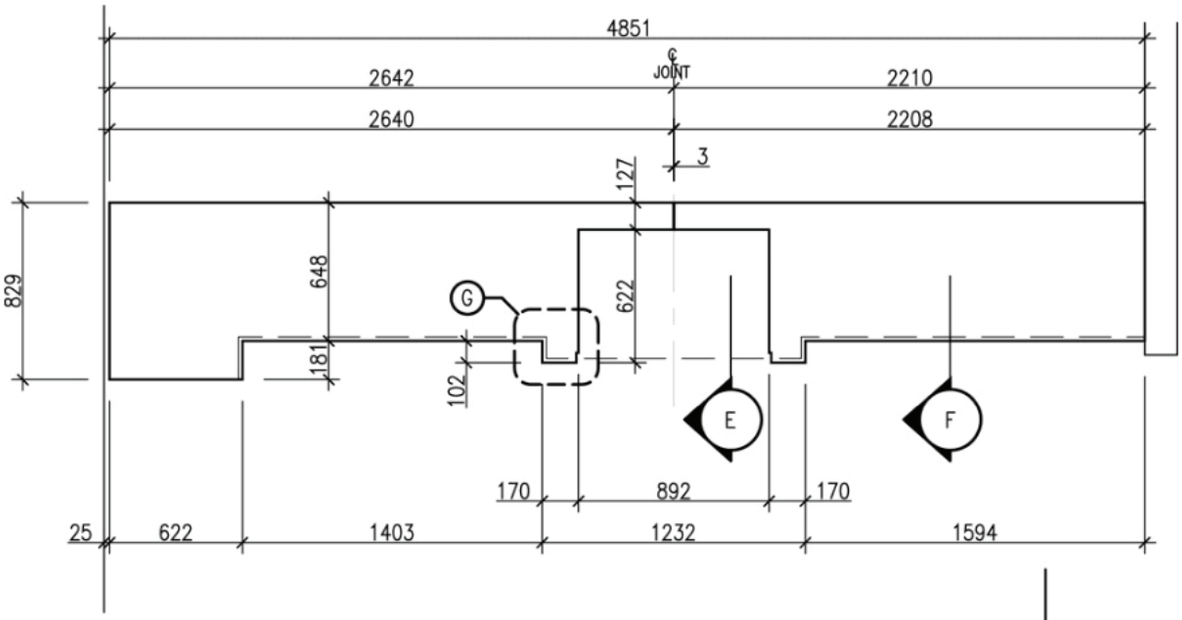




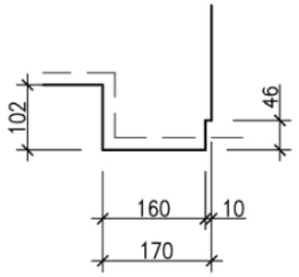
SAMPLE BATHROOM VANITY



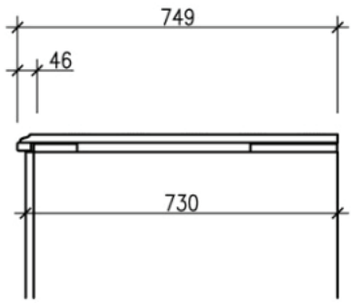
SAMPLE KITCHEN PLAN



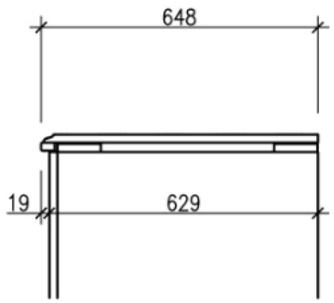
PLAN D – FINISHED GRANITE DIMENSIONS



DETAIL G

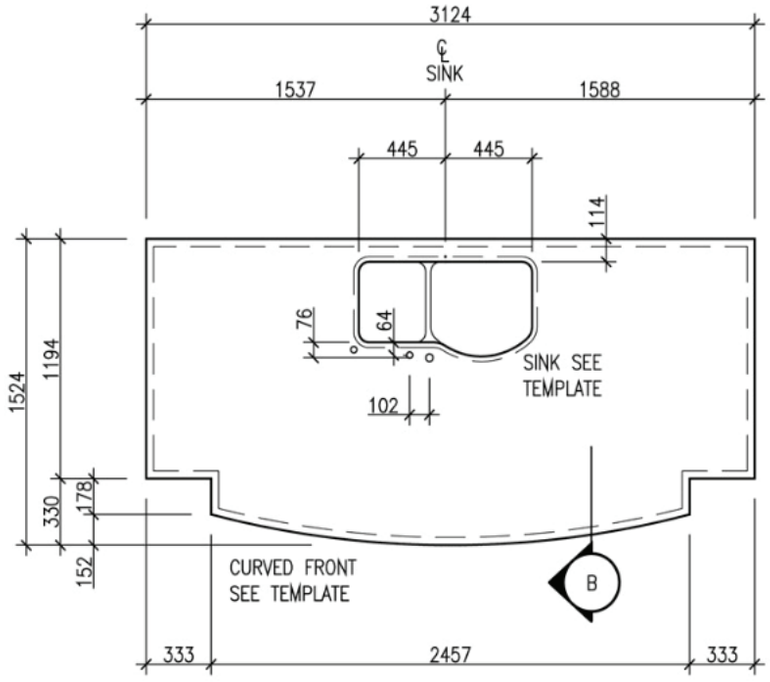


SECTION E – COOKTOP

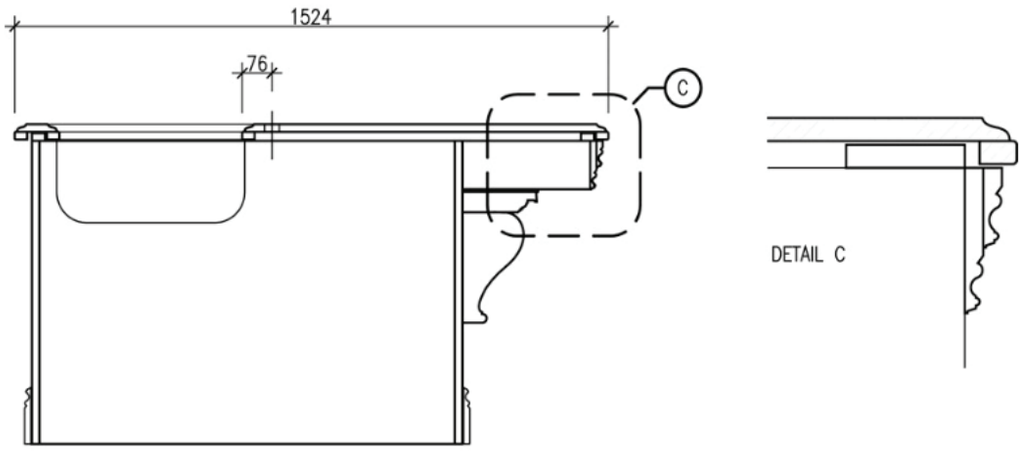


SECTION F – COUNTER

COUNTER DETAILS

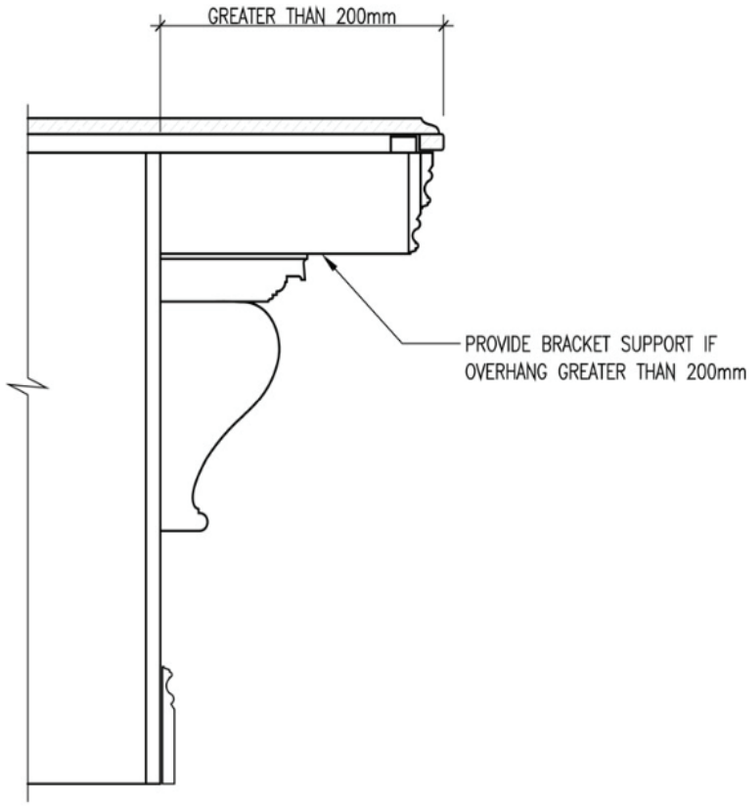


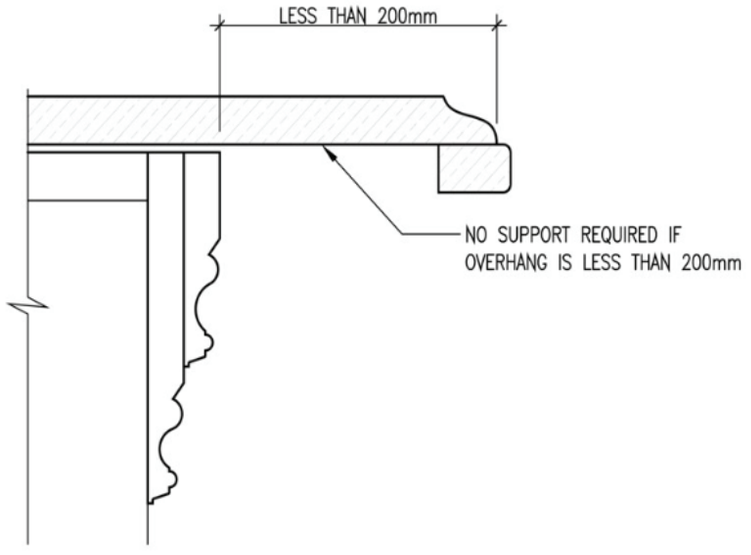
PLAN A – FINISHED GRANITE DIMENSIONS



SECTION B – ISLAND

ISLAND DETAILS





COUNTER OVERHANG DETAILS

SHOWER STALLS

The use of natural stone in up-scale condominiums and high end homes has been on the increase in recent years, mostly due to it's inherent value. Homeowners have come to appreciate its beauty, durability and performance. Many showers are being clad with 19 mm (3/4 inch) thick natural stone slabs which are pre-cut, pre-finished, fabricated in the shop to exact dimensions and delivered ready to be installed.

Installation Shower Floor

Shower floors are usually installed on wood or concrete substrates. The substrate must be designed to limit deflection to L/360. Pre-fabricated shower pan or waterproof membranes must be installed on the floor and turned up the wall at least 152 mm. Mortar bed must not be less than 25 mm in thickness at drain connection and must have a slope of 6 mm per 305 mm to drain.

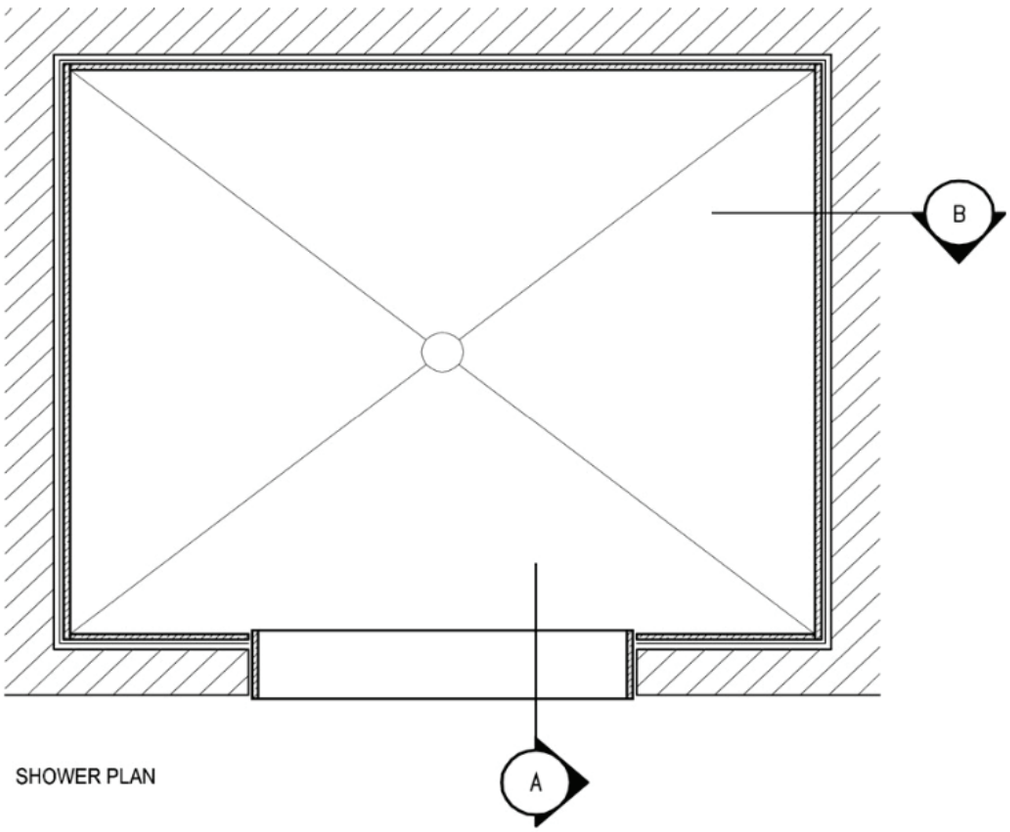
NOTE: In order to achieve a greater COF (Co-efficient of Friction) in wet area applications, 100 mm x 100 mm (4 inch x 4 inch) or smaller are generally recommended for this application. Where larger pieces are required, the slope to drain requirement must be respected.

Shower Wall Substrate

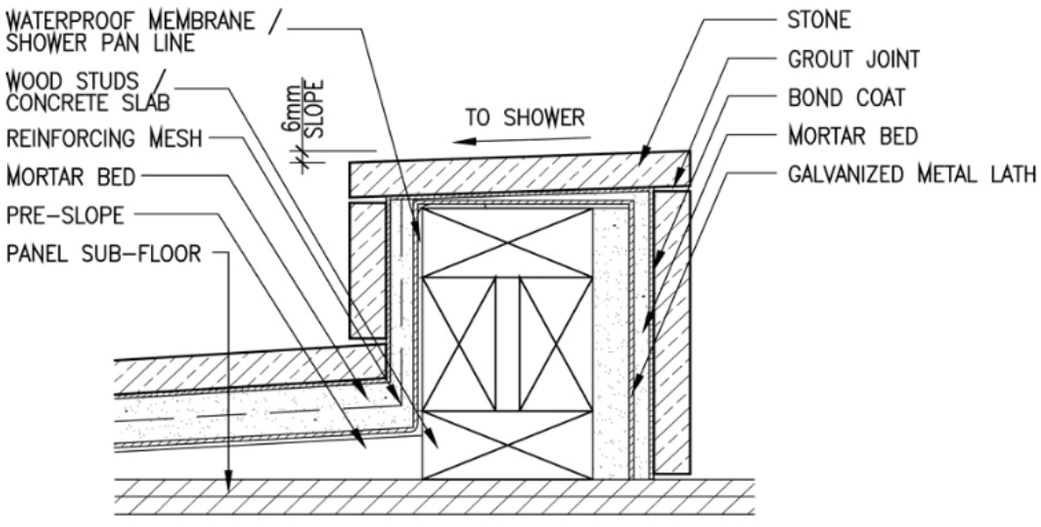
There are numerous acceptable substrates used for the installation of natural stone. The most preferred would be masonry. Alternatively coated glass mat backer board, fibre-cement backerboard or a cementitious backer unit (CBU) will provide for a suitable backup surface for the installation. The substrate must be designed stiff enough to limit the deflection to a maximum of L/360 of the span. An alternate method, is to provide a cement mortar bed. This method provides a sturdy surface where installation challenges may present custom shaped walls or curved surfaces.

Installation Systems

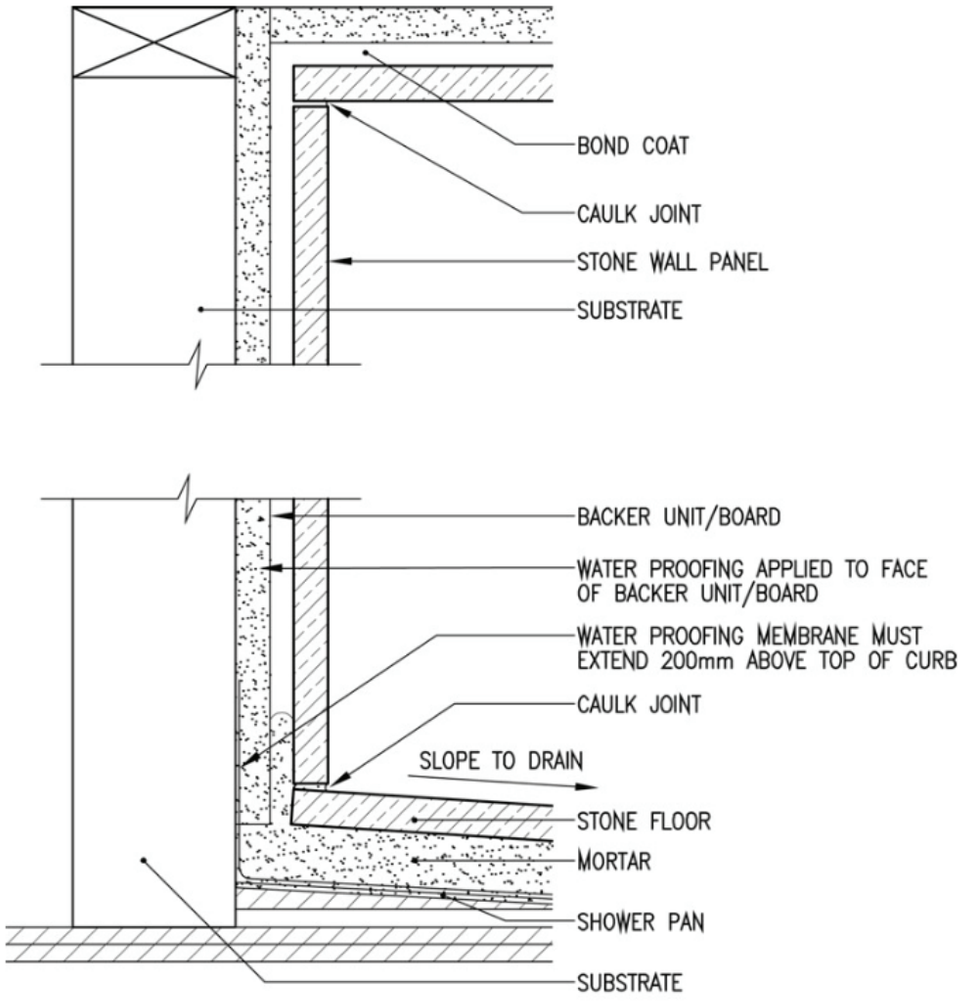
The installation system most commonly used in residential showers is to bond the slabs thin-set method on to the substrate by fully backer buttering the back of the slab and randomly setting spots for leveling purposes using latex Portland cement mortar. An alternate to using cement based setting material is to use non staining silicone. This should be approached with caution as certain light-coloured stones may be subject to staining. Silicones should be tested prior to use. The slabs can also be set using the conventional method using copper or stainless-steel wire. The wire is engaged into a drilled hole in the stone and through the sheathing tied around the self tapping screw which is drilled into the wood or metal studs framing, or the wire is looped around the stud and held in place by setting spots of cement mortar. Waterproof membrane if required must be specified (ANSI A118.10). Follow manufacturer's recommendations for installation and use. Setting material must be compatible with waterproof membrane. All openings and cuts must be treated to ensure waterproof integrity.



SHOWER PLAN



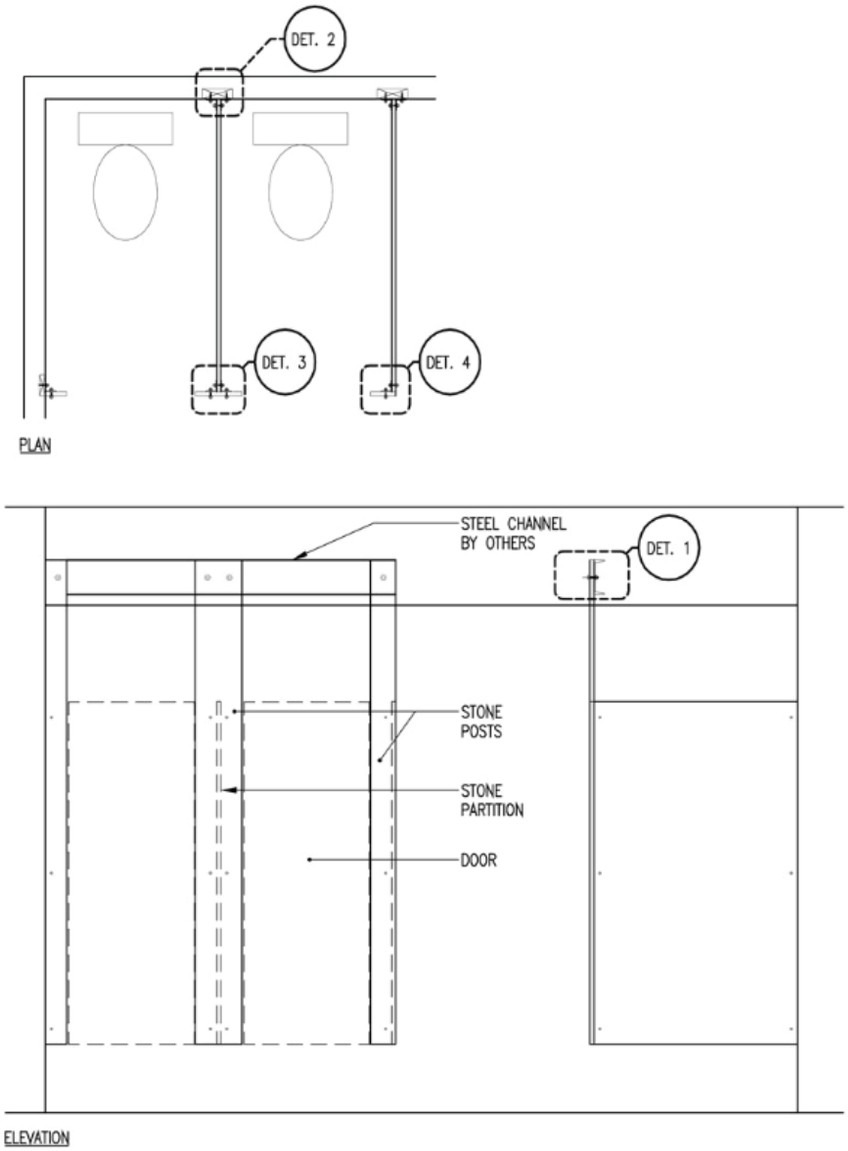
SECTION A - CURB DETAIL



SECTION B - BASE AND SOFFIT DETAIL

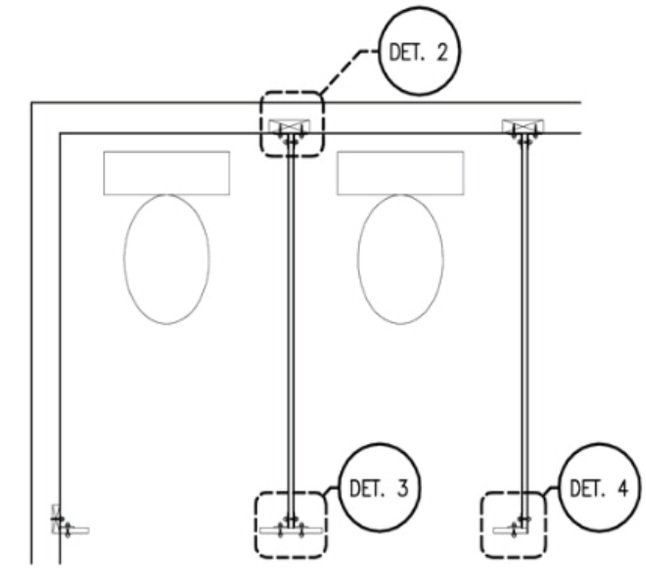
WASHROOM PARTITIONS

Stone partition installations vary depending on design criteria or site conditions. Suspended (ceiling hung) or floor bearing (floor mounted) systems are both acceptable methods of installation. Wire anchors, dowels and pins may be used in place of plated hardware. The specifier should ensure that the material selected conforms to the appropriate ASTM standards as well as being free from any cracks or other flaws that affect the structure stability of the stone panel. The stone consultant should specify the exact method of installation. Shop drawings should identify specific locations for anchors, clips and pins as well as identify the exact sizing and edge finishing.

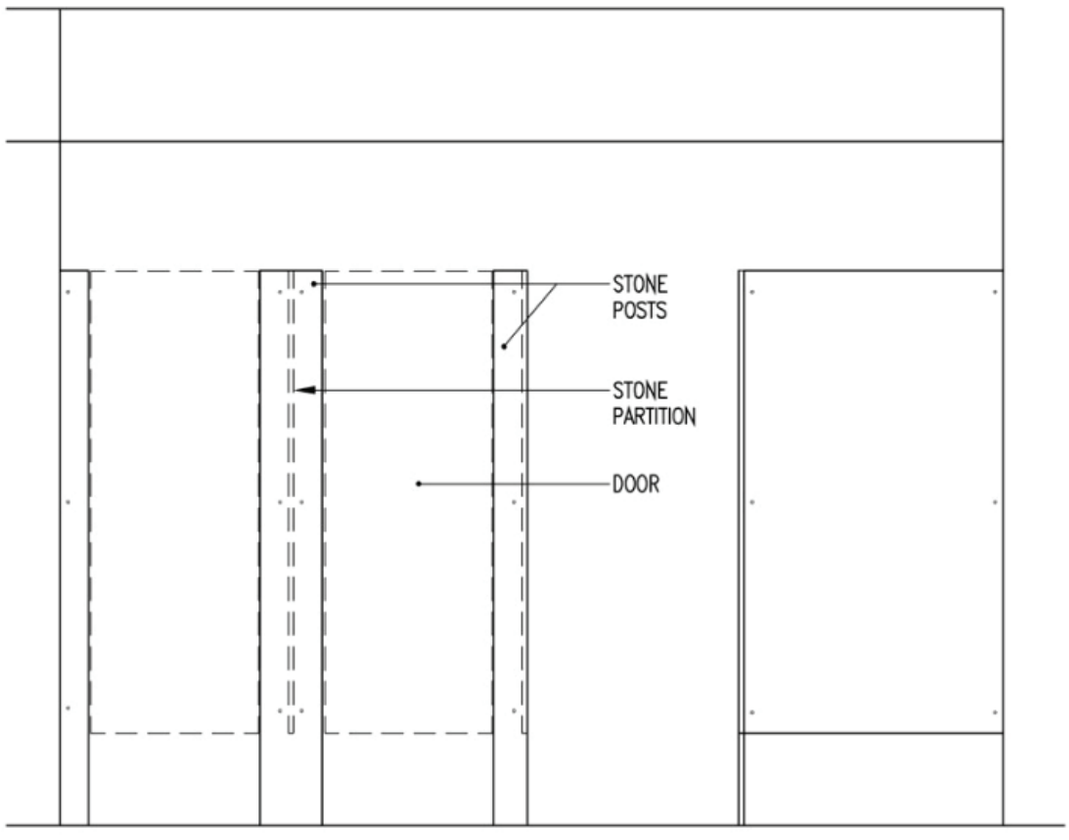


BATHROOM STALLS - SUSPENDED

Washroom Partitions Anchoring Systems



PLAN



ELEVATION

BATHROOM STALLS - BEARING ON FLOOR

Care and Maintenance

Natural stone products are porous by nature. To ensure your natural stone products will provide you with a lifetime of aesthetics and performance, proper maintenance is crucial.

New Installation

Sealing is strongly recommended for newly installed marble and other natural stone to provide maximum below surface protection.

Pre-Grouting Sealing

Non-Sanded grout is typically used for natural stone installations. This type of grout has very fine particles of cement, polymers, and colour pigments that can penetrate the microscopic pores of the stones surface where they become trapped and appear as a stain in the stone. Therefore, travertine, slate, tumbled stone, and honed/flamed/unpolished granite should be sealed with a grout releasing sealer prior to the grouting process to protect from staining. A good quality sealer may also be used as a pre-grout sealer and applied again as the final sealing process once the installation is complete.

Sealing Natural Stone

Sealers are coatings applied to the surface of the stone designed to be a protective coating. (e.g. Acrylic, natural wax, and other plastic compounds) Impregnators penetrate below the surface and become repellants. Impregnators are generally hydrophobic (water-repelling) but are also oleophobic (oil-repelling). Impregnators keep contaminants out but do not stop the interior moisture from escaping. The type of stone and the environment of the application must determine the type of treatment that is applied to the surface of the stone. All surface treatments must be used in accordance with manufacturer's specifications. Surface treatments such as topical and penetrating agents may be used when a defined benefit can be determined. Benefits from the use of surface treatments may be considered for use when:

- The risk of staining is present
- As an aid in the daily maintenance procedures.
- A coating may help preserve the stone finish in excessively high wear conditions.
- Where weathering has or might impact the integrity of the stone surface.
- To preserve the aesthetic elegance of the original installation.
- Where the risk of graffiti or other vandalism is high.

Natural Look Penetrating Sealer

A premium natural look penetrating/impregnating sealer is the normal choice on polished or honed marble, limestone, granite and slate. Penetrating/impregnating stone sealers are non-sheen, natural look sealers that can be water-based or solvent-based, good for interior and exterior applications. "Natural look" penetrating sealers are not a surface coating and will not alter the natural look of the stone.

Stone Enhancer Sealers

Stone enhancer sealers are also non-sheen, penetrating sealers that are formulated to darken, enriches, and highlight the natural colour of tumbled, antique, or slate products. They will also rejuvenate and improve the appearance of worn and weathered stone. However, they will also darken the colour of grout joints. Stone should be tested periodically to ensure the sealer is working effectively.

Care and Maintenance

Stone Care

Use cleaners specifically designed for cleaning stone. Stone cleaners should never contain acid or bleach. Acids, even a light solution of vinegar and water, will etch and eventually damage natural stone.

Stain Removal

Stains can often be removed by cleaning with an appropriate cleaning product or household chemical. Identifying the type of stain is the key to removing it. Look for color, shape and environmental factors that could be causing the staining.

- Oil Based: Include grease, tar, cooking oil, milk and cosmetics. An oil based stain will darken the stone and normally must be chemically dissolved so the source of the stain can be flushed or rinsed away. Clean gently with a soft liquid cleanser with bleach or household detergent, ammonia, mineral spirits or acetone.

- Organic: Includes coffee, tea, fruit, and tobacco, paper, and food, urine, leaves, bark and bird droppings. May cause a pinkish brown stain and may disappear after the source of the stain has been removed. Outdoors, with the sources removed, normal sun and rain action will generally bleach out the stains. Indoors, clean with a 12% hydrogen peroxide and a few drops of ammonia.

- Metal: Includes iron, rust, copper and bronze. Iron or rust stains are orange to brown in color and follow the shape of the staining objects such as nails, bolts, screws, cans, flower pots, and metal furniture. Copper and bronze stains appear as green or muddy brown and result from the action of moisture on nearby or embedded bronze, copper or brass items. Metal stains must be removed by making a poultice. Deep seated, rusty stains are extremely difficult to remove and the stone may be permanently stained.

- Biological: Includes algae, mildew, lichens, moss and fungi. To clean, dilute with 1/2 cup in a gallon (3.78 litres) of water with only one of the following: ammonia, bleach, or hydrogen peroxide. DO NOT MIX BLEACH AND AMMONIA! THIS COMBINATION CREATES A LETHAL AND TOXIC GAS!

- Ink: Includes magic marker, pen and ink. Clean with bleach or hydrogen peroxide for light colored stones. Use lacquer thinner or acetone for dark colored stones.

- Paint: Small amounts can be removed with lacquer thinner or scraped off carefully with a razor blade. Heavy paint coverage should be removed with a commercial “heavy liquid” stripper. Paint strippers can etch the surface of the stone; re-polishing may be necessary. Do not use acids or flame tools to strip paint from the stone.

- Water: Water spots and rings that include surface accumulation of hard water. Buff with dry 0000 steel wool.

- Fire and Smoke Damage: Older stones and smoke or fire-stained fireplaces may require a thorough cleaning to restore their original appearance. Commercially available “smoke removers” may save time and effort.

- Etch Marks: Usually caused by acids left on the stone. Some materials will etch the finish but not leave a stain; others will both etch and stain. Once the stain has been removed, wet the surface with clear water and sprinkle with marble polishing powder. Rub the powder into the stone with a damp cloth or by using a buffing pad with a low-speed power drill. Continue buffing until the etch mark disappears and the stone surface shines. Honing may be required for deep etching.

Efflorescence

Efflorescence is the salt residue, sometimes found on the surface of a stone caused from the migration of moisture either through the stone or deposited onto the surface. Efflorescence is very often noticed at grade. As moisture moves through the stone, most often through capillary action of a stone in contact with the ground or soil, deposits of salt are left behind as it begins to dry and the moisture evaporates. Salt saturated moisture may enter the stone in various locations. Proper drainage and setting techniques must be employed to ensure the rapid movement of salt saturated moisture away from the stone panels. Prolonged exposure to high levels of salt saturated moisture may lead to spalling. Preventing the stone from contact the grade or soil and providing positive drainage are the most effective ways to prevent efflorescence. Sealing the stone at the base may also assist in preventing efflorescence.

Poultice:

A poultice is a fine, non-acid, absorptive clay cleaning powder that may remove deep-set oil stains, grease and light cementitious grout haze from polished and unpolished natural stone.

A poultice is a liquid cleaner or chemical mixed with an absorbent material to form a paste with a thick, creamy consistency. The poultice is spread over the stained area to a thickness of 6 mm (1/4 inch) to 12 mm (1/2 inch) with a wood or plastic spatula or scraper, covered with plastic and left to work for 24 to 48 hours. The liquid cleaner or chemical will draw out the stain into the absorbent material. It may be necessary to repeat poultice procedures to thoroughly remove a stain; however, some stains may never be completely removed.

Poultice materials include kaolin, fuller's earth, whiting, diatomaceous earth, powdered chalk, white molding plaster or talc.

Poultice Cleaning Agents:

- Oil Based Stains: Poultice with baking soda and water OR one of the powder based poultice materials and mineral spirits.

- Organic Stains: Poultice with one of the powdered poultice materials and 12% hydrogen peroxide solution OR use acetone instead of hydrogen peroxide.

- Iron Stains: Poultice with diatomaceous earth and commercially available rust. Rust stains are particularly difficult to remove. Professional assistance may be required.

- Copper Stains: Poultice with one of the powdered poultice materials and ammonia. These stains are difficult to remove, professional assistance may be required.

- Biological Stains: Poultice with one of the poultice materials and diluted ammonia OR bleach OR hydrogen peroxide.

DO NOT MIX AMMONIA AND BLEACH! THIS COMBINATION CREATES A TOXIC AND LETHAL GAS!

Application of Poultice

Prepare the poultice. If using powder, mix with the cleaning agent or chemical to a paste with a thick creamy consistency. If using paper, soak the chemical and let drain. Do not let the liquid drip.

Wet the stained area with distilled water. Apply the poultice to the stained area, approximately 6 mm (1/4 inch) to 12 mm (1/2 inch) thick and extend the poultice beyond the stained area by approximately 2.5 cm (1 inch). Use a wood or plastic scraper to spread the poultice evenly. Cover the poultice with plastic and seal the edges with tape.

Allow to dry thoroughly, usually 24 to 48 hours. The drying process pulls the stain out of the stone and into the poultice material. After approximately 24 hours, remove the plastic and allow the poultice to dry. Remove the poultice from the stain, rinse with distilled water and buff dry with a soft cloth. Use a wood or plastic scraper if necessary.

Repeat the poultice application if the stain is not removed. It may take up to five (5) applications for difficult stains.

If the surface is etched by the chemical, apply polishing powder and buff with a polishing pad recommended by the polishing powder manufacturer.

Maintenance

Interior Stone

Polished finished stone has a glossy surface that reflects light and emphasizes both the color and the markings of the material. Polished stone used in interiors may appear as a wall veneer, furniture and desk tops, counter and lavatory tops, tables and stone for residential and commercial installations.

Honed finish stone has a satin smooth surface with relatively little light reflection. Honed finish stone is generally preferred for floors, treads and thresholds, and other pedestrian traffic locations where heavy traffic would wear off a polished finish.

Normal Maintenance

All stone flooring should be dust mopped with a non-treated dust mop as necessary to remove debris and dirt.

Normal maintenance involves periodic washing with clean, potable water and neutral (pH7) cleaners. Soap-less cleaner is preferred because it will minimize streaking and filming. Mild phosphates-free, biodegradable liquid dish washing soaps or powders or stone soaps are acceptable if rinsing is thorough.

Wet the stone surface with clean water. Using the cleaning solution (follow manufacturers instructions) wash in small overlapping sweeps. (Work from the bottom up if a vertical surface.) Rinse thoroughly with clean potable water to remove all traces of soap or cleaning solution, changing the water in the rinse pail frequently. Dry with a soft cloth and allow to thoroughly air dry.

Any flooring surface, regardless of how it is finished, can be slippery when wet. Promptly remove liquids or foreign materials that might result in safety hazards before permitting pedestrian traffic.

For honed finishes, a neutral (pH7) mildly abrasive cleaner may be used. Use only according to manufacturers directions.

For tables or countertops, use coasters under all glasses, particularly those containing alcohol or citrus juices. Many common foods, drinks and cosmetics contain acids that will etch or dull the surface of many stones. Use trivets or mats under hot dishes and placemats under ceramics, silver or other objects that may scratch the surface.

In food preparation areas, the stone may require a sealer or impregnator.

Exterior Stone

Exterior stone is a general term denoting stone installed in a situation where temperatures, moisture and air borne contaminants are regulated primarily or solely by the forces of nature.

Exterior stone can be used in a honed, textured or polished finish in any mode in any exterior environment. Uses include building cladding, walkways, steps or stairs, retaining walls, paving, fountains, benches, planters and decorative items such as sculptures.

Normal Maintenance

In accessible areas, routinely follow maintenance procedures as specified in the interior stone section, as applicable.

The large expanses of stone generally found on exterior applications make it impractical to perform normal maintenance on a frequent basis. Large installations, however, should be given periodic overall cleaning as necessary to remove accumulated pollutants. Easily accessible stone surfaces such as steps, walkways, fountains, etc. should be kept free of debris and soiling by periodically sweeping and water washing.

Normal maintenance should include periodic inspection of stone surfaces for structural defects, movement, deterioration or staining.

Restoration of Natural Stone

If the floor surface has holes or cracks, this area must be repaired and colour matched prior to the grinding process using epoxy or polyester compounds or a cement acrylic paste whichever is appropriate for the surface involved. All lippage must be removed by use of specific grinding. If lippage is not removed, excessive wear and damage to the various diamonds or abrasives may result. Wet grind the floor beginning with coarser abrasives, progressing to finer abrasives until the desired degree of finish is obtained. Prior to moving on to the next level of grinding, the entire floor must exhibit a uniform scratch pattern. Higher grades of diamonds or abrasives may be necessary due to the hardness of the stone. According to ASTM C97 if the average absorption of granite is 0.4% the moisture will temporarily affect the appearance of the granite causing it to “darken”. This effect disappears upon the return to dry conditions. As grinding progresses the slurry produced must be removed by the use of a wet vacuum. Before moving from one abrasive grind to a finer grind, thoroughly wash the surface to remove any residue from the previous grind or scoring will result in the next level of grinding. After completion of the final grind, wash and rinse the floor and seal.

NOTE: Instructions for restoration and maintenance of agglomerate should be obtained from the manufacturer. Polyester filling compound is used to fill larger holes, cracks and voids. Repair kits are available from the manufacturer.

Polishing of Marble Floors

This process is an alternative to a full restoration procedure to bring back and to maintain a high degree of shine to worn traffic areas. This can be achieved with polishing powders (Aluminum Oxide, Tin Oxide). These powders are usually white, but can be yellow, brown, gray or black. The abrasive powder is worked into the stone with a 175 rpm buffing machine using water and cloth or polyester fibre pads. The powder is worked into a slurry until the desired degree of shine is achieved. Remove slurry from surface with a wet pick-up vacuum or wet mop. Rinse with clean water to remove any excess powder left on the floor. Caution should be used. Some marble may polish with a very wet consistency while others may require almost buffing. Test the ratio of powder to water for suitability. Care must be taken as most polishing powders contain oxalic acid and if over used, damage to the marble will occur. If not enough is used the polish may not be achieved. This type of work requires experience and should only be performed by professionals who are specialized in the use of these materials and equipment.

Crystallization/Vitrification of Marble

These terms, have generally been used to describe a process for polishing marble by applying chemicals that react with the marble while buffing the marble surface. The chemicals used may be oxalic acid, silicon fluorides or other proprietary materials.

Crystallization chemically alters the surface of the marble and leaves a harder less permeable surface. Crystallization appears to work well in some marble and under certain service conditions. However certain types of marble may be deteriorated by the chemicals used in this process. Generally, marble used on floors should not be finished to a very high gloss but should be given a honed finish and treated with impregnators to improve resistance to staining. However, a high gloss finish on marble floors may be appropriate for light commercial and residential traffic conditions. Where a high gloss finish is desired, it may be obtained by the use of crystallization or by the application of suitable acrylic polishes. Altering the floor surface to a high gloss may affect the slip resistance. Damaged or worn floors can be reground and polished to their original lustre and appearance with the use of diamond discs and special equipment prior to crystallization. Crystallization is only possible on marble and limestone. Granite cannot be crystallized.

WARNING: Because crystallization/vitrification uses chemicals and components that transform the surface of marble and limestone, there is controversy regarding this method of restoration. Only trained craftsmen who are thoroughly familiar with this process should carry out this type of work.

Site Repairs

As we continue to employ better and faster building techniques the opportunity to incorporate changes or corrections has greatly been diminished. Lead-times to incorporate any changes have almost become non-existent. Repairing or patching material that has been damaged or changed is a necessity in order not to impede the progress of the project. Only skilled and qualified technicians should perform this type of work. Repairs must not distract from the aesthetic and strength of the completed installation.

Stain Removal

CAUTION: The treatments recommended herein for stain removal should be performed by trained and experienced personnel. Improper use may result in bleaching the grout, if a colour dye has been added.

T.S.P. is corrosive, use rubber gloves. Wash skin that has had contact with this material immediately.

The use of T.S.P. is intended for stubborn stain removal only. Other stain removal products are available. Always perform a test in an inconspicuous area first.

Prevention is better than the cure. Treat absorptive surfaces with penetrating sealers that give improved stain resistance and when spills occur, remove promptly. The methods appropriate for stain removal depend on the nature of both the stain and the type of surface that has to be cleaned. Acidic cleaners should not be used on natural stone. Acidic cleaners should be used with extreme caution or not at all. Many stains on low absorption stone may only be on the surface. Often stains can be removed by scrubbing with a cloth dampened with a mild detergent solution. If this fails, most surface stains can be removed by scrubbing with a dampened abrasive cleaner. These procedures should be tried first; particularly on absorptive surfaces in an inconspicuous area. There is a danger that if too much of a solvent for the stain is used, the stain will spread or penetrate further into the surface. If the stain has penetrated below the surface (this may occur on absorptive surfaces such as limestone, marble, slate and to a lesser extent, granite) it may be necessary to apply a poultice to attempt to draw the stain out. A poultice is made by mixing a cleaning solution with talcum powder or other fine inert powders to a paste consistency. The paste is applied on the stain at approximately 6 mm (1/4 inch) thickness and left to dry. As the paste dries it tends to draw the stain to the surface of the powder. Poultices may have to be applied repeatedly to remove a stain.

Stains should be treated as soon as possible, as they become more difficult to remove when they have dried. No one should attempt to remove stains unless they know what the stain is and why a certain type of remover is being used. Only as a last resort should chemicals be used to remove stains and by a qualified person. Stain removers dissolve the substance that causes the stain, absorb the stain; or act as a bleaching agent. Thus stain removers fall into three general classes.

1. Solvents such as mineral spirits, xylene, or chlorinated solvents which dissolve grease, chewing gum, lipstick, etc.

2. Absorbents such as chalk, talcum powder, blotting paper or cotton which absorb fresh grease or moist stains.

3. Bleaches such as household ammonia, hydrogen peroxide, acetic acid or lemon juices which discolour stains.

It is important to know the surface to be treated and the nature of the stain before trying to remove it. The maintenance staff should review the following prior to proceeding:

1. If it is a water base stain, water will remove it.
2. If it is an alcohol base stain, alcohol will remove it.
3. If it is an acid stain, an alkali will remove it.
4. If it is an alkali stain, an acid will remove it.
5. If it is a grease stain, soap or a degreaser will remove it.
6. If the stain contains albumin, as in milk or blood, do not use a hot solution as it may cook the albumin.

“Water” marks - water will not damage marble or stone although it may temporarily darken the stone. Often what looks like a watermark on marble may have been caused by acids in citrus drinks or soft drinks, which can etch the surface. Refinishing the affected area may be the only way to remove these marks.

Ink Stains

Different inks require different treatments. Ordinary writing inks may etch stone due to acid content. To remove a stain of this type, mix a solution of sodium perborate (dry hydrogen peroxide) in hot water and add whiting (such as chalk), mix to a thick paste, apply in 6 mm (1/4 inch) layer, and leave until dry. If some of the ink colour is visible after poultice is removed, repeat.

Sodium perborate may be obtained from a druggist however must be used with caution as it may cause skin irritation. Use rubber gloves; wash any affected areas with water immediately.

Many red, green, violet and other bright coloured inks are water solutions of synthetic dyes. Stains made by this type of ink can usually be removed by the sodium perborate poultice described above. Often the stain can be removed by applying ammonia water on cotton batting. Javelle water is also effective, used the same as ammonia water, or mixed to a paste with whiting and applied as a poultice. A mixture of equal parts of chlorinated lime and whiting reduced to a paste with water may also be used as a poultice material. Some blue inks contain Prussian Blue, a ferrocyanide of iron. These stains cannot be removed with the use of a perborate poultice, Javelle (Calcium or Sodium Hypochlorite) water, or chlorinated lime poultice. Such stains yield to treatment of ammonia water applied on a layer of cotton batting. A strong soap solution applied the same way may also be effective. Indelible ink often consists entirely of synthetic dyes. These types of stains may be treated as outlined above. However, some indelible inks contain silver salts that may cause a black stain. Stains of this nature may be removed with ammonia water applied by bandage.

Lubricating Oil

Lubricating oil may quickly penetrate stone and Portland cement. It should be mopped off immediately, covering the spot with Fuller's earth, or a dry powdered material such as hydrated lime, whiting or dry Portland cement. If treated soon enough, there will be no stain. However, when the oil has remained for some time, other stain removal methods may be necessary.

Saturate white Canton flannel in a mixture of equal parts of acetone and amyl acetate and place over stain. Cover with a slab of concrete or pane of glass. If the stain is on a vertical surface, improvise means to hold cloth and covering in place. Keep the cloth saturated until stain is removed. If the solvent tends to spread the stain, a larger cloth should be used. Covering the saturated cloth with glass drives the stain into the concrete, while a dry slab of concrete will absorb the stain. Scrubbing with mineral spirits or other organic solvents will often remove oil stains. Caution should be taken when using organic solvents as inhalation of the vapour and prolonged skin contact with the liquid may lead to unpleasant health effects.

Tobacco Stains

The following formula is usually effective in removing tobacco stains: Dissolve 928 g (2 lb) of tri-sodium phosphate (TSP) crystals in 3.78 litres (1 gal) hot water. Mix 340 g (12 ounces) of chlorinated lime to a paste in a shallow enameled pan by adding water slowly and mashing the lumps. Pour this and the trisodium phosphate solution into a 7.56 (2 gal) stoneware jar and add water until full. Stir well, cover the jar, and allow time to settle. To use, add some of the liquid to powdered talc until a thick paste is obtained. Apply as a 6 mm (1/4 inch) poultice with a trowel. To apply with a brush, add about one teaspoon of sugar to each 454 g (1 lb) of powdered talc.

When dry, scrape off with a wooden paddle or trowel. This mixture is a strong bleaching agent and is corrosive to metals.

Care should be taken not to drop it on coloured fabrics or metal fixtures.

This method may also be used to treat other types of stains. Tri-sodium phosphate may be purchased at drug stores, chemical supply or laundry supply houses. If the stain is not bad, grit scrubbing powders, commonly used on terrazzo, tile and marble floors are often satisfactory as a poultice material. Stir powder into hot water until mortar consistency is obtained. Mix thoroughly, and then apply to stained surface in a 12 mm (1/2 inch) layer. Leave until dry. In most cases, two or more applications will be necessary.

Coffee Stains

Coffee stains can be removed by applying a cloth saturated in glycerine diluted with four times its volume of water. Javelle water, or the solution used on iron stains, is also effective.

Iodine Stains

An iodine stain will gradually disappear on its own accord. It may be removed quickly by applying alcohol and covering with whiting or talcum powder. On vertical surfaces, mix talcum to a paste with alcohol, apply some alcohol to the stain, and then cover with paste.

Blood Stains

Blood stains can be removed by the following method:

1. Use cold water and a mild detergent to clean the area.

2. Apply a solution of cold water and tri-sodium-phosphate (T.S.P.) crystals or a solution of 50% ammonia and water, allowing it to sit for several minutes.

3. Agitate or scrub gently with a stiff scrubbing brush or nylon scouring pad.

4. Rinse with clear, cold water. Dry with a clean cloth or paper towel.

5. If the stain remains use a poultice with a powder such as ammonia and diatomaceous earth.

Chewing Gum

Chewing gum can be removed by the following method:

1. Apply ice to harden gum.

2. Scrape off with putty knife or razor blade.

3. Remove remaining traces by scrubbing with a nylon scouring pad saturated with trichloroethylene.

Caution should be used when using trichloroethylene as inhalation of the vapour and skin contact with the liquid may lead to unpleasant health effects.

Grease

Method for the removal of grease, fat, butter, salad dressing or milk varies with the conditions. Two methods are recommended:

Method 1

1. Use a strong solution of high alkaline cleaner (T.S.P. or similar product) and very hot water. - Agitate with stiff scrubbing brush.

2. Rinse thoroughly with very hot water.

Method 2

1. Apply a thin layer of thick paste of non bleaching cleanser (pumice powder) which will not discolour grout joints. Note: Other absorbents are corn meal, corn starch, talcum powder, Fuller's earth, and French chalk.

2. Next morning agitate with scrubbing brush or nylon scouring pad.

3. Rinse thoroughly with very hot water.

Glossary

Abrasive Finish: A flat, non-reflective surface finish.

Abrasive Hardness (Ha): Refers to the wearing qualities of stone for floors, stair treads, and other areas subjected to abrasion by foot traffic.

Absorption: Percentage of moisture absorption by weight; (see ASTM C97)

Acid Cleaning: Solution of inhibited acid and water used for cleaning unglazed surfaces.

Adhered: Stone veneer secured and supported by adhesion of an approved bonding material over an approved backing.

Adoquin: A volcanic quartz-based stone containing a variety of coloured aggregates and pumice in a quartz matrix. Quarried in Mexico. Available in several colours.

Agglomerated “Stone”: A product made from quarry waste.

Alabaster: Fine-grained, translucent variety of gypsum, generally white in colour. May be cut and carved easily with a knife or saw. Term is often incorrectly applied to fine-grained marble.

Alkali Carbonate Reaction (ACR): The reaction of alkalis within certain limestone aggregates which can cause expansion and cracking in concrete.

Alkali-Silica Reaction (ASR): The reaction of alkalis with aggregate (sand/rocks) with poorly crystalline and reactive silica. May cause distress to concrete.

Anchor: Metal device for securing dimension stone to a structure.

Anchorage: The means by which slabs are attached to a self-supporting structure.

Anchors: Mechanical devices for securing marble units to structural members or back-up walls.

Apron: A trim piece under a projecting stone top, stool, etc.

Arris: Edge of an external angle.

Ashlar: Stone having a square or rectangular shape.

Back buttering: placing mortar on the backside of the stone with a trowel before setting into place.

Backing: Wall surface on which stone will be applied.

Backing Rod: A flexible and compressible type of closed-cell foam polyethylene, butyl rubber, or open cell and closed cell polyurethane, rounded at surface to contact sealant. It is installed at the bottom or rear of joint. Often described as a “filler strip”.

Back-up Wall: That part of masonry wall behind the exterior veneer or facing.

Banker: Bench of timber or stone (may be a single block) on which stone is worked.

Basalt: A dark-coloured, igneous rock commercially known as granite when fabricated as dimension stone.

Base: The bottom course of a stone wall, or the vertical first member above grade of a finished floor.

Bearing Check: A slot cut into the back of dimension stone to allow entry of a supporting angle or chip.

Bed:

1. Stone set with grain running horizontally is said to set on “natural bed”. Stone set with the grain running vertically is on “edge”.

2. The top or bottom horizontal surface of a piece of stone, which is covered when the piece is set in place.

3. A filled or open space extending horizontally between adjacent pieces set in place.

Bedding Plane: Horizontal plane of sedimentary stone in position of its original formation.

Bevel: A sloped surface contiguous with a vertical or horizontal surface.

Bleed: Staining action on marble of various oil based putties, mastics and other sealants (SB).

Bond Coat: The cement, epoxy or adhesive coat applied over prepared surface or to individual slabs during setting operations.

Breccia: Rocks made up of angular fragments of still older rocks, which have been melded together over time.

Brushed Finish: Textured surface obtained by brushing a stone with a coarse rotary type wire brush. (Sometimes referred to as broom finish)

Building Stone: natural rock of adequate quality to be quarried and cut as dimension stone as it exists in nature

Buttering: Placing mortar or other jointing materials on masonry unit before laying it in place.

Calcarenite: A limestone composed predominantly of clastic sand-size grains of calcite, or rarely aragonite, commonly as tiny fossils, shell fragments, or other fossil debris.

Calcite: One of the most common minerals - calcium carbonate. It occurs in crystalline forms and is a major constituent of limestone, marble and chalk. Marble containing no more than 5% magnesium carbonate (dolomite) is sometimes called calcite marble.

Capillary Action: Saturation of the substrate caused by the rise and fall of liquid and may travel from lower to higher elevations.

Carbonation: The neutralization of the protective alkalinity of concrete caused by the absorption of dioxide and water resulting in the formation of carbonic water. May lead to corrosion issues later.

Cementitious Backer Unit (CBU): A backer board designed for use with stone. It can be used in place of metal lath, Portland cement scratch coat and mortar bed over frame construction. Should be used in place of plywood or drywall in wet areas or for exterior use.

Clearance: Space allowed facilitating erection of units and providing for thermal and other estimated movements in structure.

Cleavage Plane: An asphalt coated paper or polyethylene film installed over the structural slab providing a slip sheet to prevent transmission of structural cracks through to the flooring surface.

Coated Glass Mat Backer Board: A backer board designed for use with stone. It can also be used in non-tile applications. Should be used in place of plywood or drywall in wet areas. Not for exterior use.

Conglomerate: (Agglomerate) - Tile or slabs made up of stone chips in a cement or resin binder.

Conglomerate: A sedimentary rock consisting of rounded pebbles and cobbles in a sandstone matrix, typically strongly cemented.

Control Joint: A joint cut, formed or tooled into the concrete surface to control the location of cracks due to shrinkage and other dimensional changes in the concrete structure.

Coquina: A limestone composed predominantly of unaltered shells or shell fragments loosely cemented by calcite.

Cramp: U-shaped metal device for holding two adjacent pieces of marble together.

Cultured Stone: Artificial stone.

Curtain Wall: Exterior wall which is non-load bearing and which is supported by structural framework of building.

Cushions: Resilient pad intended to absorb or counteract severe stresses between adjoining marble slabs or marble slabs and other adjoining materials.

Dado: Marble treatment on walls which does not extend to the ceiling.

Dimension Stone: Stone that has been trimmed or cut to specified shapes and sizes.

Dolomite: A sedimentary carbonate rock (a variety of limestone) that consists largely or entirely of the mineral dolomite.

Dowel: cylindrical metal pin used in aligning and strengthening joints of adjacent pieces of marble.

Drip: A recess cut into the underside of projecting stone to divert water and prevent it from running down the face of a wall or other surface of which it is a part.

Dry Seam: Unhealed fracture which may be a plane of weakness.

Dry-set or thin-set cement: A modified Portland cement bond coat setting material with self curing properties, which when mixed, as per manufacturer's instructions, is used for stone installation.

Durability: The measure of the ability of natural building stone to endure and to maintain its essential and distinctive characteristics of strength, resistance to decay and appearance. Durability is based on the length of time that a stone can maintain its innate characteristics in use. This time will vary depending on the environment and use of the stone in question (for example, outdoor versus indoor use).

Efflorescence: A whitish powder, sometimes found on surfaces, caused by the deposition of soluble salts carried through or onto the surface by moisture.

Entasis: The curve resulting from the gradual diminishing of the diameter of the upper two thirds of a column.

Epoxy Resin: A flexible, usually thermal setting resin made by the polymerization of an epoxide and used as an adhesive.

Epoxy: Resin which forms strong, tough resilient polymers with low shrinkage during cure and good physical properties for structural applications.

Erection: The process of setting vertical dimension stone into place.

Expansion Anchor or Bolt: A socket that grips a drilled hole in stone by expanding as the bolt is screwed into it.

Expansion Joint: A joint that extends through the stone, bonding material and substrate. They are designed to allow for continuous movement in the building structure caused by expansion and/or contraction due to thermal change or other influences.

Fabricated: Dimension stone manufactured and ready for installation.

Face: Refers to the exposed surface of stone on a structure.

Filler Strip: See "Backing Rod".

Filling: The filling of natural voids in stone units with cements or synthetic resins and similar materials.

Fines: The powder, dust, silt-sized or sand-sized material resulting from stone processing.

Finish: Final surface applied to the face of dimension stone during fabrication.

Flagstone: Thin slabs of stone used for paving walks, driveways, patios, etc. They are generally fine-grained, bluestone, other quartz based stone or slate. Thin slabs of other stones may also be used.

Flamed Finish: See "Thermal Finish".

Flamed (Thermal) Surface Finish: A flamed or thermal surface finish is achieved by passing a 2,800 degree F torch flame over the surface of the stone. This process heats the various minerals and crystals and expands them until they explode or break from the body of the stone. The result of this thermal process is a coarse, irregular surface finish with an exposed port structure. The flamed finish creates a look and texture which is desirable in certain applications. However, this open porosity also exposes the stone to weathering and other moisture-bearing contaminants. Generally, only granites and a few other stones can be successfully flamed due tot he amounts of dissimilar minerals present with different coefficients of thermal expansion.

Flashing: Protection preventing infiltration of moisture.

Fleuri Cut: The "mottled" effect obtained when certain stone varieties are cut parallel to their natural bedding plane.

Gang Saw: A mechanical device, also known as a "frame saw", used to reduce stone blocks to slabs of predetermined thickness.

Gauged or Gauging: A grinding process to make all pieces of material to be used together the same thickness.

Gauged and ungauged slate:

1. Gauged slate is machined on underside for constant thickness – for adhesive, thin-set or mortar bed installations.

2. Ungauged slate a natural cleft of nominal thickness.

Glass Seam: Vein fillings of coarsely crystalline calcite that do not necessarily decrease the strength of stone.

Grain: The easiest cleavage direction in a stone "with the grain", same as "natural bed"; also, particles (crystals, sand grains, etc.) of a stone.

Granite: A hard, crystalline, igneous rock. A granular igneous rock composed principally of feldspar and quartz, with lesser amounts of dark ferrous-magnesium materials.

Greenstone: (commercial definition) A metamorphic rock, typically with poorly defined granularity, ranging in colour from medium green or yellowish green to black.

Grout: Mortar used to fill joints.

Guide Specification: Recommended specification for the finishing and installation of dimension stone.

Hand or Machine Pitch-Faced (Rock-Faced) Ashlar: A finish given to veneer stone. This is created by establishing a straight line back from the irregular face of the stone. Proper tools are then used to cut along the line, leaving a straight arris and the intended rustic finish on the face.

Hat: Specialized bracket used to fasten steel strut to substrate.

Head: The exposed surface of the jointed end of any given piece of stone whose gauged dimension is not more than the minimum thickness of the material specified.

Hone Finish (or honed): A satin smooth surface finish with little or no gloss. This finish is recommended for commercial floors.

Hydrostatic Pressure: Water pressure beneath a below grate slab driven by the forces of gravity resulting in transmission through the slab in the absence of waterproofing techniques. Igneous: One of the three great classes of rock (igneous, sedimentary and metamorphic), solidified from molten state as granite.

Importer: One who imports marble and maintains a storage yard for stocking and distributing blocks and rough sawn slabs of marble from foreign countries to marble trade in this country in substantial quantities and reliable quality.

Incise: To cut inwardly or engrave, as in an inscription.

Indiana Limestone Institute (ILI): A trade organization established for the dissemination of information on limestone standards, recommended practices, grades, colours, finishes, and all technical data required for specifying, detailing, fabricating and erecting Indiana Limestone. Publishers of the "Indiana Limestone Handbook" and other technical papers.

Installation: See "Erection".

Kerf: Slot cut into the edge of stone with a saw blade for the insertion of anchors.

Leakage: The moisture migration traveling from a higher to a lower elevation due to the force of gravity.

Leveling or straightening coat: A cement mortar applied to the surface of backing or structural slab to bring surface to a true even plane. Differs from mortar bed as the leveling coat or straightening coat is usually allowed to set up prior to installation of slate.

Limestone: Any stone consisting wholly or principally of calcite (calcium carbonate). Marble is a limestone which has been transformed (metamorphosed) over time. The variety of limestone used as a building stone is hard and lasting; it can be cut easily and shaped with saws, planes and lathes, and has a minimum of graining.

Limestone Marble: Compact, dense limestone that will take a polish is classified as marble in trade practice. Limestone marble may be sold as limestone or as marble.

Liners: Structurally sound sections of marble which are cemented and dowelled to back of marble veneer slabs with polyester, epoxy or German cement. Their purpose is to give greater strength, additional bearing surface or to increase joint depth.

Lippage: The edge of an aperture at the seam or joint of two parallel surfaces resulting in an exposed edge.

Marble: Carbonate rock that has acquired a distinctive crystalline texture by recrystallization, most commonly by heat and pressure during metamorphism, and is composed principally of the carbonate minerals calcite and dolomite, singly or in combination.

Matching: Selecting, cutting and placing finished marble slabs to obtain a uniform and symmetrical pattern of natural veining and colour.

Microcrystalline Limestone: A limestone that consists largely or wholly of crystals that are so small as to be recognizable only under magnification.

Mortar bed: The bed installed to receive stone.

Mullion: Upright division member between windows or doors of closed series.

Natural Cleft Surface Finish: A natural cleft finish is a natural surface texture that is produced by splitting or separating stones which possess natural cleaved planes such as slate. The true colour of the stone is maintained during the splitting process and the natural cleft surface creates a unique look for a variety of applications.

Non-Ferrous: Of non-iron nature.

Notched trowel: A special trowel with notched edges on two adjacent sides to facilitate the application of organic adhesive or thin-set cement to the proper thickness.

Onyx Marble: Translucent, generally layered, cryptocrystalline calcite with colours in pastel shades, particularly yellow, brown and green.

Oolitic Limestone: A limestone composed largely of the spherical or sub-spherical particles called oolites or ooliths.

Oxidization: A reaction to the loss of electrons in the metal often resulting in corrosion where the corroded metal forms an oxide, elevated temperatures increase the rate of oxidation.

Panel Wall: Non-load bearing wall consisting of panels of various materials, each panel being separately held in frame. Frame may be structural itself or be fastened to structural frame work of building.

Parging: Plastering of face of back-up wall or back of facing material with cement mortar to fill chance voids.

Pilaster: Engaged pier of shallow depth, in classical architecture it follows height and width of related columns with similar base and cap.

Plinths: Lower square part of base column. Square base or lower block of pedestal. Base block and juncture of baseboards and trim around opening.

Pointing: Final filling and finishing of mortar joints that have been raked out.

Polished Surface Finish: A glossy surface which brings out the full colour and character of the stone. The higher the sheen or polish, the more resistant the stone will be to damaging conditions such as moisture, acidic solutions, and air pollutants. Unfortunately, the higher the sheen or polish, the lower the slip resistance or coefficient of friction (COF) of the stone. Harder stones, such as granite will hold their polish longer under traffic than softer stones.

Polyethylene Film: Plastic film sheet used for curing or cleavage membrane.

Porphyry: Igneous rock characterized by distinct and contrasting sizes of course and fine grained crystals. Used as a decorative building stone.

Poultice: A moist mass of chemicals spread on a cloth and applied to remove dirt and stains.

Predella: Platform surrounding alter.

Privacy Partition: A thin stone panel between urinals; see “Urinal Screen”.

Quarrier: One who extracts natural stone from a quarry.

Quarry: Stone quarry is pit, open to air or underground from which is obtained by cutting, drilling or wire-sawing stone.

Quarry Block: generally a rectangular piece of rough stone as it comes from a quarry, frequently dressed (scabbed) or wire-sawed for shipment.

Quartz-Based Stone: This stone may be either sedimentary in formation (as in sandstone) or metamorphic (as in Quartzite). (Note: Definitions of a three classes of stone which form a Quartz-Based Stone Group are explained in ASTM C119.)

Quartzite: Classified as metamorphic sandstone, it is 95% free silica with hardness close to granite. A metamorphic quartz-based stone formed in exceedingly hard layers. In some deposits, intrusion of minerals during the formation process created unusual colouration.

Quartzite Sandstone: Sandstone containing at least 90% free silica (quartz grains plus siliceous cement), which may fracture around or through the constituent grains.

Quirk Mitre: System used where two pieces of marble from external angle constructed of beveled edge which does not extend to outside angle.

Rabbet: Type of joint used at intersection of two pieces of marble where one piece fits into a recess. The groove cut into the surface along an edge so as to receive another piece similarly cut.

Rake: An angular cut on the face of stone.

Receptor: combined floor and curb used as base for shower.

Rebated Kerf: An additional cut that countersinks a kerf from the back edge of the kerf to the back edge of another piece of stone for the purpose of additional anchor clearance. It is not a gauged cut. If used for a bearing surface, must be shimmed to allow for tolerance in the cut.

Recrystallized Limestone: A limestone in which a new pattern of crystallinity has pervasively replaced the crystal orientation in the original clastic particles, fossils or fossil fragments and interstitial cement. The new generation of crystals, encompassing both fragmental and matrix materials, extends across boundaries between former crystals. The new crystals generally are larger than those of the original rock. Evidence of original textures may or may not be retained.

Reglet: A narrow, flat recessed molding of rectangular profile.

Reinforcing Mesh: A wire mesh installed in flooring to increase tensile strength, usually 50 mm (2 inch) x 50 mm (2 inch) x 1.6 mm (1/16 inch) gauge square mesh.

Reinforcement: A fabrication technique often called “rodding”; refers to the strengthening of unsound marble and limestone by cementing rods into grooves or channels cut into the back of a stone unit. Another method of “reinforcement” is the lamination of fiberglass to the back of the stone.

Reliquary: Receptacle for relics set in marble alters.

Residual Moisture: Excessive moisture in the slab from the original concrete mixing water.

Return: See “Head”.

Reveal: The exposed portion of a stone between its outer face and a window or door set into an opening.

Rift: the most pronounced direction of splitting or cleavage of a stone (see grain). Rift and grain may be obscure, as in some granite, but are important in both quarrying and processing stone.

Rock: A naturally occurring consolidated aggregation of one or more minerals constituting the crust of the earth.

Rodding: Reinforcement of structural unsound marble by cementing reinforcing rods into grooves or channels cut into the back of slab.

Rough Sawn: A surface finish resulting from the gang sawing process.

Rubble: A term applied to dimension stone used chiefly for walls and foundations, consisting of irregularly squared pieces, partly trimmed or squared, generally with one split or finished face, and selected and specified with a size range.

Rustication: Chamfers or square sinkings around the face edges of individual stones to create shadows and to give an appearance of weight to a lower part of a building. When only horizontal joints are sunk, the device is known as banded rustication.

Saddle: Flat or shaped strip of marble projecting above finished floor surface between jambs of door threshold.

Sample: A piece of dimension stone, usually 305 mm (12”) x 305 mm (12”) showing the general range of colour, markings and finish of a given variety.

Sand Blasted: a dull non-glossy finish applied to stone; usually accomplished by blasting air blended with sand across the surface.

Sand Finished: A matte textured surface finish with no gloss; finished by application of a steady flow of sand and water under pressure. Sandstone: See “Quartz-Based Stone”.

Scabbling: See “Dressing”.

Sandstone: Composed of medium to coarse grains of sand - mainly of quartz - with iron oxide, minerals and secondary silica comprising the cementing materials.

Scarifying: process utilizing star shaped steel or carbide tipped cutters to impact the surface, chipping or tearing away particles of the floor, resulting in a rough profile. Scarifying will remove almost any material – hard or soft. A disadvantage of using the scarifying method is strong vibrations and noise. It is recommended that shot blasting or water pressure cleaning be used as a secondary process to remove micro cracked particles.

Scratch Coat: The initial cement mortar coat installed over backing usually preceding the mortar bed.

Sculpture: The work of a sculptor cutting a three dimensional form from a block of stone. Sealant: An elastic adhesive compound used to seal stone veneer joints.

Sealing: 1. To make a veneer joint water-tight or leak-proof with an elastic adhesive compound; 2. Application of a surface treatment to retard staining.

Sedimentary Rocks: Rocks formed by sedimentary deposits (mineral or organic matter deposited by water, air or ice). Marble is one example.

Serpentine Marble: A rock consisting mostly or entirely of serpentine (hydrated magnesium silicate), green to greenish-black in colour, commonly veined with calcite and dolomite or magnesite, or both (magnesium carbonate).

Setter: An experienced journeyman who installed dimension stone.

Setting: The trade of installing dimension stone.

Setting Compound: A chemical resistant setting compound sometimes used for installing slate.

Setting Space: Term used to indicate distance from finished face of piece of marble to face of back-up material.

Shear: Type of stress; body is in shear when it is subject to pair of equal forces which are opposite in direction and which act along parallel planes.

Shims: Thin pieces of metal used to adjust to exact plane. Wood, lead and aluminum not permitted.

Shot Blasting: method that cleans and profiles concrete surfaces by removing dirt, laitance, curing compounds, sealers or other contaminants in preparation for the application of protective materials.

Sill: Horizontal marble member immediately supported by foundation wall or piers and which in turn bears upright members of frame for opening in wall.

Siltstone: A fine-grained, noncarbonated clastic rock composed mostly of detrital quartz and clay minerals in which the particles have an approximate size range of 0.06 to 0.005 mm. mm. Siltstone may be designated fine-grained sandstone, and is texturally transitional between sandstone and shale.

Slate: A natural quarried fine grained metamorphic rock or material, available in multiple shapes and sized, thicknesses and colours, (Gauged or ungauged), natural cleft finish, non-slip wet or dry, other finishes available to special order. Frost proof, acid resistant, non combustible, low absorption, sanitary and easy to clean maintain.

Slurry Bond Coat: Usually a Portland cement and water mixture applied to surface of a structural slab to insure a positive bond for mortar bed.

Soffit: The underside

Soundness: Describes the degree to which untreated stone is free from cracks, faults and similar imperfections. It is of concern at the time of fabrication and installation.

Spall: A chip or splinter separated from the main mass of stone.

Spandrel: Panel of wall between adjacent structural columns and between window sill and window head next below it. Split: Division of a rock by cleavage

Split Face (Sawed Bed): Usually sawed on the stone bed and split by hand or machine so that the face of the stone exhibits the natural quarry texture.

Split Face Stone: Stone on which the face has been broken to an approximate plane.

Split Stone Finish: Obtained by sawing to accurate heights then breaking by machine to required bed widths. (Normal bed widths are 3-1/2 inch (90 mm))

Spots or Spotting: Adhesive contact, usually of plaster of Paris, applied between back of marble veneer and face of back-up wall to plumb or secure standing marble.

Sticking: Process of cementing together broken slabs or pieces of marble.

Stool: Inside sill of window.

Stringer: Defines treatment at edge of stairs, inside and outside.

Structural Slab: The flooring surface on which stone will be installed.

Struts: Supporting brace.

Styolite: Longitudinally streaked, columnar structure occurring in some marbles and of same material as marble in which it occurs.

Sulfate Attack: Salts derived from the soil and foreign to concrete via moisture intrusion that adversely affect the concrete and the covering material.

Telegraphing: A common industry term to describe cracking conditions that originate from within the assembly and/or substrate and migrate to the surface.

Template: Pattern.

Texture: The size, degree of uniformity and arrangement of the minerals contained in a piece of marble. Grains of calcite, the principal constituent of most marbles, are crystalline and have definite cleavages, showing bright reflecting faces on a broken surface. Most marble have elongated grains going in one direction.

Thermal Finish: A rough surface finish that tends to subdue the colour and markings of marble and granite.

Translucence: Translucence is one of marbles most intriguing attributes. It is dependent on four factors: 1) crystal structure, 2) colour - white and other lighter coloured marbles are generally more translucent, 3) thickness - the thicker the panel, the less light is transmitted, and 4) surface finish - smooth finishes heighten translucency, rough ones decrease it.

Travertine Marble: A porous or cellular layered partly crystalline calcite of chemical origin. Pores and cavities commonly are concentrated in some of the layers, giving rise to an open texture.

Tolerance: Dimensional allowance made for inability of men and machines to fabricate product of exact dimension.

Uncoupling Membrane: Minimizes the transfer of thermal movement, shrinkage of Portland cement, subfloor deflection, minor crack transference caused by substrate movement, etc. to the stone floor. Eliminates the need for crack isolation and anti-fracture membranes. Recommended for installation over problematic substrates.

Vapour Transmission: Process of moisture emitting through a concrete surface driven by nature through the capillaries within the concrete.

Vein: A streak or marking in marble - the result of mineral deposits. Iron oxides make the pinks, reds, yellows and browns. Most grays, blue greens and blacks are of bituminous origin. Micas, chlorite and silicates cause greens.

Veneer: Decorative facing material which is not meant to be load-bearing.

Water Vapour: Permeability – Water vapour permeability of a homogeneous material is a property of substance. This property may vary with conditions of exposure. Average permeability of specimen is product of its permeance and thickness.

Wear: The removal of material or impairment of surface finish through friction or impact.

Weathering: Natural alteration by either chemical or mechanical processes due to the action of constituents of the atmosphere, surface water or ground water, or to temperature change.

Metric Conversion Guide

To convert inches to millimetres, multiply the number of inches by 25.4 to obtain millimetres. To convert feet to millimetres, multiply the number of feet by 304.88 to obtain millimetres. To convert millimetres to feet multiply the number of millimetres by .00328 to obtain feet.

For a reference only, some common (rounded nominal) industry metric conversions to the imperial equivalents follow:

1 mm = 1/32 in	19 mm = 3/4 in	152 mm = 6 in	1000 mm = 39-3/8 in
2 mm = 1/16 in	25 mm = 1 in	180 mm = 7 in	1220 mm = 4 feet
3 mm = 1/8 in	30 mm = 1-1/8 in	203 mm = 8 in	2439 mm = 8 feet
6 mm = 1/4 in	32 mm = 1-1/4 in	280 mm = 11 in	3049 mm = 10 feet
8 mm = 5/16 in	38 mm = 1-1/2 in	305 mm = 12 in	3659 mm = 12 feet
10 mm = 3/8 in	51 mm = 2 in	356 mm = 14 in	4878 mm = 16 feet
11 mm = 7/16 in	75 mm = 3 in	406 mm = 16 in	
13 mm = 1/2 in	102 mm = 4 in	480 mm = 19 in	
16 mm = 5/8 in	125 mm = 5 in	610 mm = 24 in	

Appendix A – Stone Reference Information

The following reference is a general listing and may not contain all stones. Contact the supplier for additional information.

Durability

1 Heavy Commercial: Suitable for most commercial and/or high traffic areas.

2 Medium/Light Commercial: Suitable for light commercial and residential use.

3 Light Residential: Suitable for residential use. Not recommended for commercial areas.

Colour Variations

L Low: Background colour is relatively uniform.

M Medium: Background colour contains slight variations.

H High: Background colour contains distinct variations.

R Random: Variegated in colour and veining. Blending allowances during installation are strongly recommended.

Special Notes:

■ Not recommended in wet areas unless sealed properly as part of normal maintenance. May contain areas of open or dry seams that can appear dull under reflective light.

♦ Might contain dry seams, pits, fossils and glass veins that are filled at the factory or during installation. Since these voids can sometimes lose their fillings, they should be refilled as part of normal maintenance.

● A sealer is recommended.

☒ Suitable for exterior application in freezing and non-freezing climates.

❁ White thin-set or mortar is recommended. (Note: Limestone and Tumbled Natural Stone should be sealed prior to grouting.)

❖ Install with a water-free epoxy thin-set. Do not use any water setting material.

Polished surfaces are not recommended for floor areas subject to standing water or grease accumulation.

Exterior Usage

- Limestone, Travertine, Tumbled Natural Stone and Slate are suitable for exterior application in non-freezing climates ONLY. Some slates are suitable for exterior application in freezing climates, see usage guide.
- Granite is suitable for exterior application in freezing and non-freezing climates.
- Marble is not recommended for exterior application. Prolonged exposure to the sun and other natural elements may cause variation in the appearance of the stone (colour, shade, finish, etc.)
- Polished natural stone is not recommended for exterior floor applications.

Marble

COLOUR	FINISH	DURABILITY	VARIATION	SPECIAL NOTES
Thassos White	Polished	2	L	■ ♦ • ❁
Carrara White	Polished	1	L	■ ♦ • ❁
Carrara Gioia	Polished	1	L	■ ♦ • ❁
Botticino Semi Classico	Polished	1	M	■ ♦ •
Botticino Fiorito	Polished	1	M	■ ♦ •
Breccia Oniciata	Polished	3	H	■ ♦ •
Cedar Oniciata	Polished	3	H	■ ♦ •
Crema Marfil Elegance	Polished	1	L	■ ♦ •
Crema Marfil Classic	Polished	1	M	■ ♦ •
Rojo Alicante	Polished	2	M	■ ♦ •
Emperador Dark	Polished	1	M	■ ♦ •
Empres Green Dark	Polished	1	M	■ ♦ • ❖
Hulien Jade Green Medium	Polished	1	M	■ ♦ • ❖
China Black	Polished	2	M	■ ♦ • ❖
Cherry Blossom	Polished	1	M	■ ♦ •
Champagne Gold	Honed	1	M	■ ♦ •
Crema Aurora	Polished	1	M	■ ♦ •
Crema Azul	Polished	1	M	■ ♦ •
Jerusalem Antique Gold	Polished	2	M	■ ♦ •
Damascus Gold	Polished	1	M	■ ♦ •
Damascus Gold	Honed	1	M	■ ♦ •

Travertine

COLOUR	FINISH	DURABILITY	VARIATION	SPECIAL NOTES
Navona Travertine	Polished	2	M	■ ♦ • ❁
Navona Travertine	Honed	2	M	■ ♦ • ❁
Roman Travertine	Polished	2	L/M	■ ♦ • ❁
Cross Cut Torreon	Honed	2	L/M	■ ♦ • ❁
Walnut Travertine	Honed	2	M	■ ♦ • ❁
Coral Travertine	Honed	2	H	■ ♦ • ❁
Durango Travertine	Honed	2	H	■ ♦ • ❁
Baja Cream	Honed	2	L/M	■ ♦ • ❁
Mediterranean Ivory	Honed	2	M	■ ♦ • ❁
Sienna Gold	Honed	2	H	■ ♦ • ❁
Antalya Dark	Honed	2	H	■ ♦ • ❁

Tumbled Natural Stone

COLOUR	FINISH	DURABILITY	VARIATION	SPECIAL NOTES
Sand	Natural	2	M	■ ♦ • ❁
Coral	Natural	2	H	■ ♦ • ❁
Walnut	Natural	2	H	■ ♦ • ❁
Emerald	Natural	2	L/M	■ ♦ • ❁
Midnight	Natural	2	L/M	■ ♦ • ❁
Almond Beige	Natural	2	L/M	■ ♦ • ❁
Jade Green	Natural	2	M	■ ♦ • ❁
Baja Cream	Natural	2	L/M	■ ♦ • ❁
Champagne Gold	Natural	2	L/M	■ ♦ • ❁
Sienna Gold	Natural	2	H	■ ♦ • ❁
Mediterranean Ivory	Natural	2	M	■ ♦ • ❁
Antalya Dark	Natural	2	M	■ ♦ • ❁
Crema Marfil	Natural	2	M/H	■ ♦ • ❁
Emperador Dark	Natural	2	M	■ ♦ • ❁
Rojo Alicante	Natural	2	M	■ ♦ • ❁
Botticino	Natural	2	M	■ ♦ • ❁
Indian Multicolour	Natural	2	R	■ ♦ • ❁
Autumn Mist	Natural	2	R	■ ♦ • ❁
Silver Gray	Natural	2	H	■ ♦ • ❁
Copper	Natural	2	H	■ ♦ • ❁

Granite

COLOUR	FINISH	DURABILITY	VARIATION	SPECIAL NOTES
Sapphire Blue	Polished	1	M	• ☒
Silver Sea Green	Polished	1	M	• ☒
Madurai Gold	Polished	1	M	• ☒
Golden Garnet	Polished	1	L	• ☒
Verde Marataca	Polished	1	M	• ☒
Tunas Green	Polished	1	L	• ☒
Verde Butterfly	Polished	1	L	• ☒
Giallo Antico	Polished	1	L	• ☒
Santa Cecilia Yellow	Polished	1	M	• ☒
Tan Brown	Polished	1	L	• ☒
Golden Leaf	Polished	1	M	• ☒
Tropical Brown	Polished	1	L	• ☒
Impala Black	Polished	1	L	• ☒
Luna Pearl	Polished	1	L	• ☒
Luna Pearl	Flamed	1	L	• ☒
Blue Pearl	Polished	1	L	• ☒
Baltic Brown	Polished	1	L	• ☒
Emerald Pearl	Polished	1	L	• ☒
Almond Mauve	Polished	1	L	• ☒
Mystic Mauve	Polished	1	L	• ☒
Ubatuba	Polished	1	L	• ☒
Giallo Veneziano	Polished	1	M	• ☒
Cafe Imperial	Polished	1	L	• ☒
Absolut Black	Polished	1	L	• ☒
Absolut Black	Flamed	1	L	• ☒
Galaxy Black	Polished	1	L	• ☒
Juparana Colombo	Polished	1	M	• ☒
Violetta	Polished	1	L	• ☒
Dakota Mahogany	Polished	1	L	• ☒
Dakota Mahogany	Flamed	1	L	• ☒

Limestone

COLOUR	FINISH	DURABILITY	VARIATION	SPECIAL NOTES
Jurastone Beige	Honed	1	L	■ ♦ • ❁
Jurastone Grey-Blue	Honed	1	L	■ ♦ • ❁
St. Herbert	Honed	2	L	■ ♦ • ❁
Gascoigne Blue	Honed	1	L	■ ♦ • ❁
Jerusalem Antique Gold	Honed	2	L	■ ♦ • ❁

Slate

COLOUR	FINISH	DURABILITY	VARIATION	SPECIAL NOTES
Brazil Green	Natural Cleft	2	L	■ • ☒
Brazil Black	Natural Cleft	2	L	■ • ☒
California Gold	Natural Cleft	2	R	■ • ☒
Indian Multicolour	Natural Cleft	2	R	■ • ☒
Autumn Mist	Natural Cleft	2	R	■ • ☒
Sunset Glory	Natural Cleft	2	R	■ • ☒
Copper	Natural Cleft	2	R	■ • ☒
Imperial Forest	Natural Cleft	2	R	■ • ☒
Mongolian Spring	Natural Cleft	2	R	■ • ☒
China Apricot	Natural Cleft	2	R	■ • ☒
Golden Sun	Natural Cleft	2	R	■ • ☒
Golden Sun Flagstone	Natural Cleft	2	R	■ • ☒
Red	Natural Cleft	2	L	■ • ☒
Black	Natural Cleft	2	L	■ • ☒
Variegated	Natural Cleft	2	L	■ • ☒
Grey/Green	Natural Cleft	2	L	■ • ☒
Mottled Purple	Natural Cleft	2	L	■ • ☒

APPENDIX B MASTER SPECIFICATIONS

INTERIOR HORIZONTAL STONE SPECIFICATION SECTION

1 General

2 Summary

3 This Section includes requirements for supply and installation of the following:

4 Interior stone flooring

5 [Stair treads]

6 [Crack isolation membranes] [Waterproofing membranes]

7 Stone flooring accessories including [bases] [, edge strips] [, transition strips] [, control strips] [, movement joints] [, stair nosings] and other accessories required for a complete and finished installation.

8 RELATED SECTIONS

SPEC NOTE: Edit to suit.

9 Section 03 31 00 – Structural Concrete

10 Section 03 35 00 – Concrete Finishing

11 Section 05 51 00 – Metal Stairs

12 Section 06 10 00 – Rough Carpentry

13 Section 07 92 00 – Joint Sealers.

14 REFERENCES

SPEC NOTE: Delete references not required; add others if necessary.

14.1.1 American National Standards Institute (ANSI):

15 ANSI A108-2020, Specifications for the Installation of Ceramic Tile

16 ANSI A118.1-2019, American National Standard Specifications for Dry-Set Cement Mortar

17 ANSI A118.3-2021, American National Standard Specifications for Chemical Resistant, Water Cleanable Tile-Setting and -Grouting Epoxy and Water Cleanable Tile-Setting Epoxy Adhesive

18 ANSI A118.4-2019, American National Standard Specifications for Modified Dry-Set Cement Mortar

19 ANSI A118.5-1999(R2021), American National Standard Specifications for Chemical Resistant Furan Mortars and Grouts for Tile Installation

20 ANSI A118.6-2019, American National Standard Specifications for Standard Cement Grouts for Tile Installation

21 ANSI A118.7-2019, American National Standard Specifications for High Performance Cement Grouts for Tile Installation

22 ANSI A118.8-1999(R2021), American National Standard Specifications for Modified Epoxy Emulsion Mortar/Grout

23 ANSI A118.9-2019, American National Standard Specifications for Test Methods and Specifications for Cementitious Backer Units

24 ANSI A118.10-2014(R2019), American National Standard Specifications for Load Bearing, Bonded, Waterproof Membranes for Thin-set Ceramic Tile and Dimension Stone Installation

25 ANSI A118.11-2017, American National Standard Specifications for EGP (Exterior Glue Plywood) Latex-Portland Cement Mortar

26 ANSI A136.1-2021, American National Standard Specifications for Organic Adhesives for Installation of Ceramic Tile

27 ANSI A137.1-2022, Standard Specifications for Ceramic Tile

27.1.1 American Society for Testing of Materials (ASTM International):

28 ASTM A82/A82M-07, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement (WITHDRAWN)

29 ASTM A185/A185M-07, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement (WITHDRAWN)

30 ASTM C144-18, Standard Specification for Aggregate for Masonry Mortar

31 ASTM C171-20, Standard Specification for Sheet Materials for Curing Concrete

32 ASTM C207-18, Standard Specification for Hydrated Lime for Masonry Purposes

33 ASTM C241/C241M-20, Standard Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic

34 ASTM C373-18, Standard Test Methods for Determination of Water Absorption and Associated Properties by Vacuum Method for Pressed Ceramic Tiles and Glass Tiles and Boil Method for Extruded Ceramic Tiles and Non-tile Fired Ceramic Whiteware Products

35 ASTM C503/C503M-15 Standard Specification for Marble Dimension Stone

36 ASTM C568/C568M-15, Standard Specification for Limestone Dimension Stone

37 ASTM C615/C615M-18e1, Standard Specification for Granite Dimension Stone

38 ASTM C616/C616M-15, Standard Specification for Quartz-Based Dimension Stone

39 ASTM C627-18, Standard Test Method for Evaluating Ceramic Floor Tile Installation Systems Using the Robinson-Type Floor Tester

40 ASTM C629/C629M-15, Standard Specification for Slate Dimension Stone

41 ASTM C648(2020), Breaking Strength of Ceramic Tile

42 ASTM C847-18, Standard Specification for Metal Lath

43 ASTM C1028-07e1, Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method (WITHDRAWN)

44 ASTM C1178/C1178M-18, Standard Specification for Coated Glass Mat Water-Resistant Gypsum Backing Panel

45 ASTM C1597M-04(2009)e1, Standard Specification for Gypsum Wallboard (Hard Metric Sizes) (WITHDRAWN)

45.1.1 Canadian Standards Association (CSA Group):

46 CSA A3000-18, Cementitious Materials Compendium

47 CSA A123.3-05(R2020), Asphalt Saturated Organic Roofing Felt

48 CSA O121-17, Douglas Fir Plywood

49 CAN/CSA O151-17, Canadian Softwood Plywood

50 CSA O153-19, Poplar Plywood

51 CSA O325-21, Construction Sheathing

52 CSA O437 Series-93(R2011), OSB and Waferboard

53 Canadian General Standards Board (CGSB):

54 CAN/CGSB 25.20-95, Surface Sealer for Floors

55 CAN/CGSB-51.34-M86, Vapour Barrier, Polyethylene Sheet for Use in Building Construction (Withdrawn)

56 CAN/CGSB 75.1-M88, Tile, Ceramic (Withdrawn)

56.1.1 Terrazzo, Tile and Marble Association of Canada (TTMAC):

57 TTMAC Installation Manual and Specification Guide 09 30 00, 2019-2021

58 2017-2019 Hard Surface Maintenance Guide

58.1.1 Underwriters Laboratories of Canada (ULC):

59 CAN/ULC S701.1-17, Standard for Thermal Insulation, Polystyrene Boards

59.1 administrative Requirements

59.1.1 Pre-Construction Meeting: Arrange a preconstruction meeting in accordance with Section 01 31 19 – Project Meetings, to discuss installation techniques, confirm compatibility of materials, identify any concerns arising from site conditions and identify any concerns of the installer or supplier, attended by [Constructor], Consultant, stone installer and stone supplier, mortar and grout representative and [waterproof] [crack control] membrane representative.

59.1.2 Coordination: Close spaces to traffic during stone installation and a minimum of 48 hours after installation; install flooring and accessories after other finishing operations, including painting and ceiling construction have been completed and as follows:

SPEC NOTE: Include requirement for coordination when tile layout and coordination with alignment of fixtures mounted to tile is a project requirement.

60 [Coordinate alignment of miscellaneous specialties, fixtures and other components penetrating tiling installation is critical to final appearance of the Project.]

SPEC NOTE: The National Floor Covering Association has prepared a free guide specification section for the interior floor finishing (https://www.nfca.ca/education-calendar/concrete-specification/).

60.1.1.1 Coordinate floor flatness and levelling requirements of this section with requirements of Section 01 84 21 – Interior Concrete Floor Finishing Performance Requirements, Section 03 35 00 and Section 09 05 61; work of this Section includes floor levelling and patching required to meet flooring manufacturer's installation requirements; notify Consultant where differences occur between specified tolerances and actual conditions.

60.2 Submittals

60.2.1 Provide required information in accordance with Section 01 33 00 – Submittal Procedures:

60.2.2 Action Submittals: Provide the following submittals before starting any work of this Section:

60.2.2.1 Product Data: Submit manufacturer's product data for each type of product specified. Data shall indicate compliance with specification and installation recommendations of manufacturer of products being used.

SPEC NOTE: Delete 1.5.2.2 below if stone and grout colours have been specified.

60.2.2.2 [Samples for Initial Selection: Submit samples for initial selection by Consultant:]

60.2.2.2.1 Stone Tile: Manufacturer's colour charts consisting of actual stone tiles or sections of stone tiles showing the full range of colours, textures, and patterns available for each type and composition of stone tile indicated. Include Samples of accessories involving colour selection.

60.2.2.2.2 Grout: Manufacturer's colour charts consisting of actual sections of grout showing the full range of colours available for each type of grout indicated.

SPEC NOTE: Quantity and size of samples must be noted, and whether they are mounted on panels with specified grout or submitted loose.

61 Samples for Verification: Submit samples for verification including sample sets showing the full range of variations expected where products involve normal colour and texture variations:

61.1.1.1.1 Stone Tile: Submit [one (1)] [two (2)] [four (4)] pieces of each stone tile [specified] [selected].

61.1.1.1.2 Submit [300 mm x 300 mm] sized panel using [specified] [selected] material [including coloured grout] mounted on 19 mm thick plywood backer.

61.1.1.1.3 Trims: Full size units of each type of trim and accessory for each colour required; 150 mm lengths.

61.1.1.1.4 [Sample Panel: Submit stone tile sample showing installation of perimeter accessories, control or movement joints and trims where applicable, using selected grout colours.]

61.1.2 Informational Submittals: Provide the following submittals during the course of the work:

61.1.2.1.1 Certificates: Submit written statements from manufacturers indicating compatibility with respect to other manufacturer's materials where more than one manufacturer's products form a part of a single stone tile assembly.

61.2 project Closeout Submissions

61.2.1 Operation and Maintenance Data: Submit copies of TTMAC Maintenance Guide in accordance with Section 01 78 23 – Operation and Maintenance Data, and additional materials as follows:

61.2.1.1 Provide stone supplier's specific warning of any maintenance practice or materials that may damage or disfigure the finished Work.

61.2.1.2 Provide stone supplier's maintenance data sheets for floor sealers and other non-stone tile maintenance materials and accessories.

61.2.2 Maintenance Materials: Deliver maintenance materials to Owner in accordance with Section 01

78 43 – Spare Parts as follows:

61.2.2.1 Deliver minimum [1] [4 litre] [20 litre] container of cleaning products specified for maintenance cleaning in item 2.8.3.2 below and store as directed by Owner.

61.2.2.2 Deliver stone maintenance materials from the same colour/dye lot in the following quantities:

61.2.2.2.1 Stone: [2%] of total installation with a minimum of [8] pieces of each colour and type

61.2.2.2.2 Trim Units: [3%] of total installation consisting of full size units of each type, composition, colour, and pattern

61.3 Quality Assurance

61.3.1 Qualifications: Provide proof of qualifications when requested by Consultant:

61.3.1.1 Standard of work for this Section: Provide materials and workmanship in accordance with recommendations of Terrazzo, Tile and Marble Association of Canada (TTMAC) and the material and installation standard contained in the referenced standards.

61.3.1.2 Supplier: Obtain materials from one source with resources to provide products from the same production run for each contiguous area of consistent quality in appearance and physical properties.

61.3.1.3 Materials: Stone that does not meet a Grade 1 Standard, or is marked as a factory second or discount will be rejected, immediately removed from the site and replaced with specified materials.

61.3.1.4 Installers: Execute Work of this Section using qualified personnel skilled in ceramic tile installation, that is a member in good standing of TTMAC at time of Bidding having proven experience completing tile installations similar in material, design, and extent to that indicated for this Project.

SPEC NOTE: Dry laid mock-ups are our cheapest quality control checkpoint, so should form the least level of due diligence for confirming tile layouts and design.

61.4 [Mock-Ups]

61.4.1 Provide required [Mock-ups] [Sample Installations] in accordance with Section 01 45 00 – Quality Control:

61.4.1.5 Obtain Consultant's acceptance of mock-ups before proceeding with final unit of Work.

61.4.1.1 [Dry lay sample installation] [Construct mock-ups] for each form of construction and finish required to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution.

61.4.1.2 Mock-up one (1) typical [washroom] [shower room] [ ] indicating tile pattern, grout colour and accessories:

61.4.1.2.1 Mock-up room will be used to coordinate placement of miscellaneous specialties and other related components as well as clearances to adjacent appurtenances (electrical and mechanical fixtures) and finishes, and as follows:

- Align miscellaneous specialties and fixtures centred over grout line intersections.
- Notify contributing trades of stone offsets and clearances required to centre fixtures.

61.4.1.2.2 Consultant will require modifications pertaining to aesthetics and placement of components that interfere with other materials or fixtures.

61.4.1.2.3 When identified modifications to the mock-up room are completed, reviewed, and accepted by the Consultant, they will form the standard of acceptance for the remainder of the Work.

61.4.1.3 Locate mock-ups in the location and of the size indicated or, if not indicated, as directed by Consultant.

61.4.1.4 Notify Consultant seven (7) days in advance of the dates and times when mock-ups will be constructed.

61.4.1.6 [Maintain mock-ups during construction in an undisturbed condition as a standard for judging the completed Work. When directed, demolish and remove mock-ups from Project site.]

61.4.1.7 [Accepted mock-ups in an undisturbed condition at the time of Substantial Performance may become part of the completed Work.]

61.5 [Delivery, Storage, and Handling]

61.5.1 Delivery and Acceptance Requirements: Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use in accordance with ANSI A108.1 for labelling sealed tile packages.

61.5.2 Storage and Handling Requirements: Store materials to prevent damage or contamination to materials by water, freezing, direct sunlight, foreign matter, and other causes; store cementitious materials in a dry area, and blocked off floor and ground surfaces.

61.6 Site Conditions

61.6.1 Ambient Conditions: Apply stone after completion of work by other Sections is complete; to surfaces sufficiently dry, clean, firm, level, plumb and free from oil or wax or any other material deleterious to tile adhesion and as follows:

61.6.1.1 Temperature: Maintain stone materials and substrate temperature between TTMAC recommended minimum and maximum temperature range; unless indicated otherwise by manufacturer, for 48 hours before and during installation until materials are fully set and cured; provide additional heat during winter months or at any other time when there is a risk that surface temperatures may drop below minimum recommended temperatures.

61.6.1.2 Ventilation: Maintain adequate ventilation where Work of this Section generates toxic gases or where there is a risk of raising relative humidity to levels that could damage building finishes and assemblies.

62 Products

62.1 Manufacturers

62.1.1 Basis-of-Design Products: Products named in [this Section] [Section 09 06 00] were used as the basis-of-design for the project; manufacturers listed as additional Acceptable Products and that offer similar products may be incorporated into the work of this Section provided they meet the performance requirements established by the named products.

62.1.2 Substitutions: Consultant may consider additional manufacturers having similar products to Acceptable Products Manufacturers listed above during the construction period, provided they meet the performance requirements established by the named products and provided they submit requests for substitution in accordance with Section 01 25 00 – Substitution Procedures before starting any work of this Section:

62.1.2.1 Do not use substitute materials to establish Bid Price.

62.1.2.2 Substitutions that appear as a part of the project without review and acceptance by the Consultant will be rejected and replaced with one of the specified materials.

SPEC NOTE: Preselect and name exact stone, stair treads and/or trim required wherever possible. Otherwise specify standard, type, class, size, colour, and pattern.

63 Performance Criteria

64 Colour Consistency: Factory blend stone tiles that exhibit colour variations within ranges selected and package so stone tile units taken from one package show the same range in colours as those taken from other packages.

65 Dynamic Coefficient of Friction: Stone installed on walkway surfaces shall have the following values as determined by testing identical products in accordance with ANSI A137.1, and as follows:

66 Level Surfaces: Minimum 0.42 wet.

67 Ramp Surfaces: greater than 0.42 wet.

SPEC NOTE: Stone panel as well as total assembly must be able to meet or surpass the testing requirements under conditions similar to actual specified usage or environments.

68 Traffic Level Performance: stone to meet [extra heavy] [heavy] [moderate] [light] [residential] traffic level performance passing ASTM C627, cycles 1 through [14] [12] [10], as described in 09 30 00, and as follows:

69 Extra Heavy: Passes cycles 1 through 14.

70 Heavy: Passes cycles 1 through 12.

71 Moderate: Passes cycles 1 through 10.

72 Light: Passes cycles 1 through 6.

3 Residential: passes cycles 1 through 3.

74 Floor Level Tolerances: Provide materials to attain floor levelness tolerances required by this Section; calculate quantity of materials based on the difference between the specified tolerance and the initial tolerance specified in Section 03 35 00; measurements will be made in the same manner as used in Section 03 35 00.

75 Stone Materials

76 Stone [Floor]: [___ x ___] mm size, [___] mm thick; Type [____], Class MR [1] [2] [3] [4] [5] [6] [7]; [_____] by [_____], [_____] colour [as selected by Consultant].

76.1.1 Marble: Provide marble tiles meeting requirements of TTMAC and ASTM C503/C503M, selected for architectural finish in sizes, colours and finish as indicated [on Drawing A#.##] [in Section 09 06 00 – Finish Schedule] and as follows:

76.1.1.1 Classification: [I Calcite] [II Dolomite].

76.1.1.2 Soundness Group: [A Sound, free from spalls cracks, open seams, pits or other defects impairing structural integrity] [B Natural Faults] [C Geological Faults] [D Maximum Faults], with flaws, voids and lines filed with polyester wax or epoxy cement.

76.1.1.3 Absorption by Weight (%): Maximum [0.20] in accordance with ASTM C97.

SPEC NOTE: Minimum Densities listed below must be selected based on classification as follows I Calcite = 2600, and II Dolomite = 2800.

76.1.1.4 Density (kg/m3): Minimum [2600] [2800] in accordance with ASTM C97.

776.1.1.5 Compressive Strength (MPa): Minimum [52] in accordance with ASTM C170.

76.1.1.6 Modulus of Rupture (MPa): Minimum [6.9] in accordance with ASTM C99.

76.1.1.7 Abrasive Hardness Value: Minimum [10.0] in accordance with ASTM C241 or ASTM C1353.

76.1.1.8 Basis of Design Products: [Refer to Section 09 06 00] [List Product]

76.1.2 Limestone: Provide limestone tiles meeting requirements of ASTM C568/C568M, selected for architectural finish in sizes, colours and finish as indicated on Drawings and as follows:

76.1.2.1 Classification: [III High Density] [II Medium Density] [I Low Density] in accordance with ASTM C568/C568M.

76.1.2.2 Absorption by Weight (%): Maximum [3] [7.5] [12] in accordance with ASTM C97.

76.1.2.3 Density (kg/m3): Minimum [2560] [2160] [1750] in accordance with ASTM C97.

76.1.2.4 Compressive Strength (MPa): Minimum [55] [28] [12] in accordance with ASTM C170.

76.1.2.5 Modulus of Rupture (MPa): Minimum [6.9] [3.4] [2.8] in accordance with ASTM C99.

76.1.2.6 Abrasive Hardness Value: Minimum [10.0] in accordance with ASTM C241 or ASTM C1353.

76.1.3.7 Basis of Design Products: [Refer to Section 09 06 00] [List Product]

76.1.4 Slate: Provide slate tiles meeting requirements of ASTM C629/C629M, selected for architectural finish in sizes, colours and finish as indicated on Drawings and as follows:

76.1.4.1 Classification: [I Exterior] [and] [II Interior]

76.1.4.2 Absorption by Weight (%): Maximum [0.25] [0.45] in accordance with ASTM C121.

76.1.4.3 Modulus of Rupture (MPa): Minimums in accordance with ASTM C120.

76.1.4.3.1 Across Grain: [62] [50]

76.1.4.3.2 Along Grain: [50] [38]

76.1.4.3.3 Abrasive Hardness Value: Minimum of [8.0] in accordance with ASTM C241 or ASTM C1353.

76.1.4.4 Basis of Design Products: [Refer to Section 09 06 00] [List Product]

77 [Base: coved; size, colour and texture to match adjacent flooring material.]

78 [Stair Treads: bull nosed edge, [non-slip surface], matching material, sized to suit stair tread configuration.]

SPEC NOTE: It is recommended the following materials are supplied by a single source manufacturer.

79 MORTAR, ADHESIVE AND GROUT

80 Portland Cement: to CSA A3000, Type GU.

81 Hydrated Lime: to ASTM C207, Type [N] [NA] [S] [SA].

82 Sand: to ASTM C144, passing 16 mesh.

83 Dry-Set Portland Cement Mortar: to ANSI A118.1.

84 Latex-Portland Cement Mortar: to ANSI A118.4.

85 Commercial Portland Cement Grout: to ANSI A118.6.

86 Latex-Portland Cement Grout: to ANSI A118.6.

87 Polymer Modified Grout: to ANSI A118.7.

88 Epoxy Adhesive and Grout: to ANSI A118.3.

89 Modified Epoxy Emulsion Mortar: to ANSI A118.8.

90 Furan Mortars and Grout: to ANSI A118.5.

91 Exterior Grade Plywood (EGP) Latex-Portland Cement Mortar: to ANSI A118.11.

92 Membranes

92.1.1 [Crack Isolation Membranes: Load bearing, pre manufactured self adhering lightweight fabric reinforced crack isolation membrane; nominal 1 mm thick manufactured to accommodate in-plane substrate movement in thin set applications meeting requirements of ANSI A108.12.]

92.1.2 [Crack Isolation Membranes: Load bearing, liquid applied lightweight fabric reinforced crack isolation membrane; manufactured to accommodate in plane substrate movement in thin set applications meeting requirements of ANSI A108.12.]

92.1.3 [Waterproofing Membranes: Load bearing, reinforced, liquid applied membrane; manufactured to accommodate flood testing and reduce the incidence of thermal shock cracking to tiling installations; meeting requirements of ANSI A108.1.]

SPEC NOTE: Preformed membrane listed below is specifically intended for thin set tile application in shower and other wet areas.

92.1.4 [Preformed Waterproofing Membrane System: Meeting requirements of ANSI A108.10, soft polyethylene membrane with fleece webbing laminated on both sides complete with special cut width rolls and special shapes for corners and pipe sleeves [, and manufacturers standard floor drain assembly].]

Manual Details 313F and 325F for floors where directly bonding stone to an unstable substrate could lead to failure of the installation.

92.1.5 [Uncoupling Membrane: Rigid polyethylene membrane with a grid structure of square cavities 3 mm high each cut back in a dovetail configuration having anchoring fleece laminated to underside [or non-directional, non-deteriorating woven mat [10 mm] [16 mm] thick] complete with manufacturers recommended floor adhesives and setting materials.]

93 [Cleavage Membrane: [[0.10 mm] [4 mil] thick polyethylene film, to CAN/CGSB 51.34] [asphalt saturated roofing felt, to CSA A123.3, Type 1].]

94 ACCESSORIES

95 Underlayment: [as specified under Section 06 10 00.] [[16 mm] thick Douglas Fir plywood, to CSA O121.]

96 Metal Lath: galvanized type, 1.4 kg/m3 to ASTM C847.

97 Reinforcing Mesh: [51 x 51 mm] mesh size, fabricated from 1.6 mm thick galvanized steel wire; welded fabric design.

98 Latex Additive: formulated for use in Portland cement mortars and grouts.

SPEC NOTE: Uncoupling membrane listed below is specifically intended for use in TTMAC 09300

99 Water: potable, clean and free of chemicals and contaminants detrimental to mortar or grout mixes.

100 Thresholds: [_____] marble, granite, limestone, slate [_____] mm thick, [rounded edges] [bevelled [one side] [two sides]], honed finish on exposed surfaces, size to suit door opening and frame width.

101 Transition Strips: purpose made metal extrusion; [stainless steel] [brass] [zinc] [anodized aluminium] type.

102 Reducer Strips: purpose made metal extrusion; [stainless steel] [brass] [zinc] [anodized aluminium] type; maximum slope of 1:2.

103 Prefabricated Movement Joints: purpose made, having a Shore A Hardness not less than 60 and elasticity of plus or minus 25 percent when used in accordance with TTMAC movement joint details.

104 Joint Sealant: as specified under Section 07 92 00.

105 Sealer: to CAN/CGSB 25.20, Type [1] [2]; as recommended by stone supplier.

106 MIXES

107 Slurry Bond Coat: mix Portland cement and water to a creamy paste consistency. Include latex additive where required by TTMAC Detail.

108 Leveling Coat (by volume): 1 part Portland cement, 4 parts sand, and latex additive where required by TTMAC Detail. Premixed mortar may be used per manufacturer's instructions.

109 Mortar Bed for Floors: 1 part Portland cement, 4 parts sand, and latex additive where required

by TTMAC Detail. Premixed mortar may be used per manufacturer's instructions. Adjust water volume depending on moisture content of sand to obtain consistency and workability. When mixed with water the mortar bed shall be of such a consistency and workability that will allow maximum compaction during tamping of the mortar bed, and achieve a minimum compressive strength of 15 MPa after 28 days. A stronger mix can be achieved by adding latex instead of water.

110 Execution

111 EXAMINATION

111.1.1 Testing and Inspections: [Test concrete substrates in accordance with ASTM F2170, and as described in Section 09 05 61] [Test moisture content of wood subfloor prior to installing stone flooring, using electronic moisture test equipment], and as follows:

111.1.1.1 Provide 72 hours notice to the Consultant of commencement of the Work.

111.1.1.2 Include cost of testing as a part of the price for work of this section.

111.1.1.3 [Do not install flooring over concrete slabs until slabs have cured and are sufficiently dry to bond with adhesive, as determined by flooring manufacturer's recommended bond and moisture test, and as follows:]

111.1.1.3.1 Confirm manufacturer's recommended relative humidity rate before starting testing.

111.1.1.3.2 Moisture tests must be conducted on all concrete slabs and is especially critical where low VOC or water-based adhesives are specified.

111.1.1.3.3 Maintain a minimum temperature of 13°C for substrates during testing operations.

111.1.2 Examine materials ordered for the project before delivering to the site; open boxes and confirm that materials match accepted samples, are free from defects and breakage detrimental to final appearance and installation, and as follows:

111.1.2.1 Consultant will only accept Grade 1 Standard, materials appearing on site factory marked as seconds or discounted or that are not consistent with materials submitted for review will be rejected.

111.1.2.2 Replace unacceptable Products at no additional cost to the Owner; order replacement materials using most expedient delivery method to minimize effect on construction schedule.

111.1.3 Examine substrates, areas, and conditions where tile will be installed for compliance with requirements for installation tolerances and other conditions affecting performance of installed tile and confirm the following:

111.1.3.1 Verify that substrates for setting tile are firm; dry; clean; free from oil, waxy films, and curing compounds; and are within starting flatness tolerances as specified in Section 03 35 00, and are ready for application of levelling materials specified in this Section.

111.1.3.2 Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of Work, and similar items located in or behind tile have been completed before installing tile.

111.1.3.3 Verify that joints and cracks in tile substrates are coordinated with tile joint locations; adjust joints in consultation with Consultant where joints are not coordinated.

111.1.3.4 [Verify that concrete substrates have been allowed to cure for a minimum of 90 days in accordance with TTMAC requirements.]

111.1.3.5 Verify that tile subject to colour variations has been blended in the factory and packaged so tile units taken from one package show the same range of colours as those taken from other packages. If not factory blended, blend tiles at site before installing.

111.1.3.6 Verify that back of tile is free from contamination before installation.

111.1.4 Notify Consultant in writing of any conditions that are not acceptable; do not proceed with installation until unsatisfactory conditions have been corrected.

112 Concrete floors scheduled to receive thin-set applied stone or cleavage membranes must be steel troweled to a fine broom finish. Finish concrete slabs to a maximum permissible variation of 6 mm in 3050 mm from the required plane when measured from high points in the surface.

113 Concrete floors scheduled to receive stone applied over a bonded mortar bed must be screed finished. Verify substrate surface variation does not exceed 6mm in 3050 mm.

113.1 [Waterproofing] [and] [Crack Isolation] [Uncoupling] Membrane Installation

114 Install cleavage membrane over structural concrete slab. If a cleavage membrane is being applied over a rough surface, apply a 6 mm thick sand-bed under the cleavage membrane.

115 PREPARATION

SPEC NOTE: Use first option for concrete substrate, use second option for wood substrate.

115.1.1 [Prepare floors in accordance with Section 09 05 61 to surface profile required by flooring manufacture.] [Securely screw underlayment to subfloor, smooth face up. Space sheets 6 mm apart.]

SPEC NOTE: The intent of the following item is not to have a specification to turn an 8 mm out of tolerance floor slab into an in tolerance 3 mm floor slab. Floor tolerances should be specified in Section 03 35 00, and should be enforced. Levelling of floor slabs by trades should be restricted to filling the occasional dip or ridge, i.e.: a slightly out of tolerance floor area of 4 mm to 3 mm.

Specify self levelling mortar only where there is a concern for severe out of tolerance construction, and only with the approval of the structural engineer since additional levelling materials, where they add significant thickness, could affect the load bearing capacity of the to floor construction.

115.1.2 Make backing surfaces level and true to a tolerance in plane of ±3 mm in 3050 mm for floors using [Levelling Bed Mortar] [Self Levelling Mortar].

SPEC NOTE: Specify the following only where extensive floor levelling is anticipated, and only when accepted by the structural engineer. Adding significant thickness of self levelling grouts can affect the load bearing capacity of the floor.

115.1.3 [Prepare floors with a medium sandblast finish to a minimum Concrete Surface Profile 5 in accordance with ICRI Guideline 03732 prior to applying any self levelling grouts.]

115.1.4 Use trowellable levelling and patching compounds in accordance with tile setting material manufacturer's written instructions to fill cracks, holes, and depressions.

115.1.5 Remove protrusions, bumps, and ridges by sanding or grinding.

116 Protect surrounding work from damage or disfiguration.

SPEC NOTE: Where finished floors are to be flush with adjacent floors, ensure that concrete slabs have been designed to be depressed the thickness of the mortar bed, bond coat and stone.

117 Installation

118 Install materials to requirements of TTMAC Dimensional Stone Guide, as scheduled below.

119 Fit stone units around corners, fitments, fixtures, drains and other built-in objects to maintain uniform joint appearance.

120 Lay out stone according to drawings and patterns.

121 Prior to installation ensure that the back of each panel is free of contaminants.

122 Wipe any residue from back side of stone. Backbutter underside of stone with bonding material and tamp it firmly to underbed while underbed is still in a workable plastic state to a true level plane. Use sufficient bond coat to ensure 90% contact. Coverage shall be evenly distributed to give maximum support to the stone. Allow underbed and bond coat to cure prior to grouting. Force grout into full depth of joint, remove excess grout and clean.

123 Clean excess bonding material from surface prior to final set.

124 Sound panels after setting materials have cured and replace hollow sounding stone before grouting.

125 Use sufficient bond coat to ensure minimum 80% contact. Bonding material must be evenly dispersed and pressed into the back of the stone.

126 Keep two-thirds of the depth of grout joints free of setting material.

127 Protect exposed edges of stone with appropriately sized transition strips. Provide reducer strips where uneven transitions between 6 mm and 12.5 mm occur.

128 CONTROL JOINTS

SPEC NOTE: Verify that the location of expansion, control, cold or seismic joints are indicated on the drawings. Use the following table to determine placement of control and expansion joints on the drawings. If not included on drawings, consider including table as part of specification.

Environment	Minimum	Maximum	Joint Width
Interior	4878 mm	6098 mm	2 mm minimum
Interior / Sunlight	2439 mm	3659 mm	4 mm minimum

129 Install control joints and expansion joints in stonework in accordance with TTMAC Detail 301MJ.

130 Keep all control and expansion joints free of setting materials.

131 GROUTING

SPEC NOTE: Epoxy grout must be installed in a dust free environment and protected for 7 days.

132 Allow proper setting time prior to grouting.

133 Pre-seal stone requiring protection from grout staining.

134 Force grout into joints to ensure dense finish.

135 Remove excess with clean cloth or sponge.

SPEC NOTE: Inspection may be part of the Verispec Program provided by the TTMAC.

136 SITE QUALITY CONTROL

137 Inspect completed work and replace broken, cracked, hollow sounding or damaged panels.

138 TOLERANCES

139 Set and level stone flush with adjacent panels.

140 CLEANING

141 Apply floor sealer in accordance with manufacturer's instructions.

142 PROTECTION

143 General contractor to provide appropriate protection to completed stone work. Protect work of other trades. Prohibit traffic during installation and for 48 hours after completion. Protect floor from impact and vibration for a minimum of 48 hours after installation. Protect base from impact, vibration,

Notes :

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