Slate

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Marble Institute of America
380 East Lorain St. Oberlin, Ohio 44074
Telephone: 440-250-9222
Fax: 440-774-9222
www.naturalstoneinstitute.org

SLATE

1.0 GENERAL

1.1 Related Documents

1.1.1 Drawings and general provisions, including General and Supplementary Conditions of the Contract and Division I Specification sections, apply to this section.

1.2 Applicable Publications

1.2.1 The following publications listed here and referred to thereafter by alphanumeric code designation only, form a part of this specification to the extent indicated by the references thereto:

1.2.2 ASTM International (ASTM):

1.2.2.1 C629, Standard Specification for Slate Dimension Stone

1.2.2.2 C120, Standard Test Methods of Flexure Testing of Slate (Modulus of Rupture, Modulus of Elasticity)

1.2.2.3 C121, Standard Test Method for Water Absorption of Slate

1.2.2.4 C217, Standard Test Method for Weather Resistance of Slate

1.2.2.5 C241, Standard Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic

1.2.2.6 C880, Standard Test Method for Flexural Strength of Dimension Stone

1.2.2.7 C1353, Standard Test Method Using the Taber Abraser for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic

1.2.3 Marble Institute of America (MIA):

1.2.3.1 Membership, Products, and Services Directory

1.2.3.2 Dimension Stone Design Manual

1.2.3.3 Additional publications may be available from the MIA Bookstore. Go online at www.marble-institute.com.

1.3 Scope of Included Work

1.3.1 The work to be completed under this contract includes all labor and materials required for the furnishing and installation of all slate work shown or called for on the contract drawings, specifications, and addenda.

1.4 Definition of Terms

1.4.1 The definitions of trade terms used in this specification shall be those published by the MIA or ASTM International.

1.5 Source of Supply

1.5.1 All slate shall be obtained from quarries having adequate capacity and facilities to meet the specified requirements, and by a firm equipped to process the material promptly on order and in strict accord with specifications. The Specifying Authority (architect, designer, engineer, contracting officer, end user, etc.) reserves the right to approve the Material Supplier for slate prior to the award of this contract. Stone and workmanship quality shall be in accordance with Industry Standards and Practices as set forth by the MIA.

1.6 Samples

1.6.1 The Slate Contractor shall submit through the General Contractor, for approval by the Specifying Authority, at least two sets of samples of the various kinds of slate specified. The sample size shall be 1'-0" x 1'-0" and shall represent approximately the finish, texture, and anticipated range of color to be supplied.

One set of samples shall be retained by the Specifying Authority, and one set shall be returned to the Slate Supplier for his/her record and guidance. It is noted herein that slate is a natural material and will have intrinsic variations in color, markings, and other characteristics. Color variation range is to be only from natural markings in the slate or from the reflective sheen and shadow value of the graining of the natural-cleft textures and cleavage planes. Depending on slate selected and quantity required, a range mockup may be used to further define the characteristics of the material. Cost of mockup, if required, shall not be included in this section.

1.6.2 Prior to fabrication, an inspection and approval by the Specifying Authority and/or General Contractor and/or End User of the finished slabs is recommended to understand the finish and full range of the material.

1.7 Shop Drawings

1.7.1 The Slate Contractor shall submit through the General Contractor, for approval by the Specifying Authority, sufficient sets of shop drawings showing general layout, jointing, anchoring, stock thickness, and other pertinent information. These drawings shall show all bedding, bonding, jointing, and anchoring details along with the net piece dimensions of each slate unit. One copy of the approved shop drawings shall be retained by the Specifying Authority, one copy shall be retained by the General Contractor, and one copy returned to the Slate Contractor for fabrication. NO FABRICATION OF SLATE SHALL BE STARTED UNTIL SUCH DRAWINGS HAVE BEEN FULLY APPROVED AND MARKED AS SUCH. The Slate Contractor shall not be responsible for determining, making, or verifying (1) design, structural, wind, seismic, or other design loads; (2) engineering estimates; (3) plans or specifications; (4) the types, sizes, or locations of anchors; or (5) verification of field dimensions, unless specifically added to the scope of work.

1.8 Defective Work

1.8.1 Any piece of slate showing flaws or imperfections upon receipt at the storage yard or building site shall be referred to the Specifying Authority for determination as to responsibility and decision as to whether it shall be rejected, patched, or redressed for use. Any material in question should not be installed prior to inspection and approval.

1.9 Repairing Damaged Stone

1.9.1 Chips at the edges or corners may be patched, provided the structural integrity of the stone is not affected and the patch matches the color and finish of the natural stone so that it does not detract from the stone's appearance.

2.0 MATERIALS

2.1 Slate

2.1.1 General: All slate shall be of standard architectural grade, free of cracks, seams, starts, or other traits which may impair its structural integrity or function. Inherent color variations characteristic of the quarry from which it is obtained will be acceptable. Texture and finish shall be as shown in the sample(s) approved by the Specifying Authority.

2.1.2 ASTM C629 [C120] [C121] [C217] [C241] See the chart of applicable ASTM standards and tests in the Appendix.

2.1.3 Schedule: Slate shall be provided as follows:

2.1.3.1 For (*state location on building*) (*state name and color*) slate with a (*type*) finish, supplied by (*name company or list several approved suppliers*).
2.1.3.2 Provide information as in (1) for each different slate/finish combination in the project.

2.1.4 Finishes: Face finish of all exterior panels should be natural cleft. Sand-rubbed, honed and other finishes are available, depending on the Slate Supplier. All exposed edges should be honed to remove saw marks and darken the edge color.

2.1.4.1 Finishes listed in the schedule shall conform with definitions by the MIA or ASTM International.

2.2 Setting Mortar

2.2.1 Mortar for setting and pointing shall be one part portland cement and one part plastic lime hydrate to three to five parts of clean, nonstaining sand. It shall be mixed in small batches, using potable, non-alkaline water with a pH of 7, until it is thoroughly homogeneous, stiff, and plastic. After mixing, the mortar shall set for not less than one hour or more than two hours before being used.

2.3 Pointing Mortar

2.3.1 Mortar for pointing shall be Type N, as defined in ASTM C270 (Standard Specification for Mortar for Unit Masonry). All mixing, handling, and placing procedures shall be in accordance with ASTM C270.

2.4 Sealants and Backup Material (If Applicable)

2.4.1 Where specified, (*state type or name of sealant*) shall be used for the pointing of joints. The backup material used with the sealant shall be (*identify material*)

2.5 Anchors, Cramps, and Dowels

2.5.1 All wire anchors, cramps, dowels, and other anchoring devices shall be nonferrous metal of the types and sizes shown on approved shop drawings. Doweling natural-cleft slate to slate is not acceptable.

3.0 FABRICATION

3.1 Dimensional Limitations

3.1.1 Slate spandrels, panels, and wall facings are recommended in thicknesses of 1", 1¼", and sometimes 1½". Standard economical lengths are up to 6'-6" and widths up to 4'-0". Special larger sizes are available to meet design and job conditions on special request. No single piece is recommended to be over 9'-6" in length or 5'-0" in width. Larger sizes may be available only under special conditions and limited production.

3.2 Beds and Joints

3.2.1 Bed and joint width shall be determined by analysis of anticipated building movements and designed to accommodate such movements without inducing undue stresses in the stone panels or joint filler materials. Expansion joints shall be designed and located to accommodate larger movements.

3.2.2 Some slight lippage and variation is natural and unavoidable where the natural-cleft face comes together at the sawed joints.

3.2.3 Joints 3/8" or ½" are recommended between standard size panels, and ¼" and 3/8" joints at abutting masonry. All joints are to be water- and moisture-tight and caulked with a proper sealant.

3.3 Backs of Pieces

3.3.1 Backs of pieces shall be sawn or roughly dressed to approximately true planes. Back surfaces shall be free of any matter that may create staining.

3.4 Moldings, Washes, and Drips

3.4.1 Moldings, washes, and drips shall be constant in profile throughout their entire length, in strict conformity with details shown on approved shop drawings. The finish quality on these surfaces shall match the finish quality of the flat surfaces on the building.

3.5 Back-checking and Fitting to Structure or Frame

3.5.1 Stone coming in contact with structural work shall be back-checked as indicated on the approved shop drawings. Stones resting on structural work shall have beds shaped to fit the supports as required.

3.5.2 Maintain a minimum of 1" between stone backs and adjacent structure. (Note: many bolted connections will require more space than this; 2" space may be more desirable. Large-scale details should illustrate and control these conditions.)

3.6 Cutting for Anchoring, Supporting, and Lifting Devices

3.6.1 Holes and sinkages shall be cut in stones for all anchors, cramps, dowels, and other tieback and support devices per industry standard practice or approved shop drawings. However, additional anchor holes shall be drilled at job site by Slate Contractor to facilitate alignment.

3.6.2 No holes or sinkages will be provided for Slate Contractor's handling devices unless arrangement for this service is made by the Slate Contractor with the Slate Fabricator.

(NOTE: It is not recommended that lewis pins be used for stones less than 3½" thick.)

3.7 Cutting and Drilling for Other Trades

3.7.1 Any miscellaneous cutting and drilling of stone necessary to accommodate other trades will be done by the Slate Fabricator only when necessary information is furnished in time to be shown on the shop drawings and details, and when work can be executed before fabrication. Cutting and fitting, due to job site conditions, will be the responsibility of the Slate Contractor.

3.7.2 Incidental cutting such as for window frame clips, etc., which is normally not considered to be the responsibility of the Stone Supplier, will be provided only by arrangement by the General Contractor and Slate Contractor with the Slate Fabricator.

4.0 SHIPPING AND HANDLING

4.1 Packing and Loading

4.1.1 Finished slate shall be carefully packed and loaded for shipment using all reasonable and customary precautions against damage in transit. No material which may cause staining or discoloration shall be used for blocking or packing.

4.2 Site Storage

4.2.1 Upon receipt at the building site, the slate shall remain in the factory-prepared bundles until beginning of the installation. Bundles shall be staged in an area which is least susceptible to damage from ongoing construction activity. Once unbundled, the slate shall be stacked on timber or platforms at least 2" above the ground, and the utmost care shall be taken to prevent staining or impact damage of the slate. If storage is to be prolonged, polyethylene or other suitable, nonstaining film shall be placed between any wood and finished surfaces of the slate. Polyethylene or other suitable, nonstaining film may also be required as protective covering.

5.0 INSTALLATION

5.1 General Installation

5.1.1 Installation shall be accomplished with competent, experienced Stone Setters, in accordance with the approved shop drawings.

5.1.2 All slate stone pieces shall be identified with a unique piece number corresponding with the number on the shop drawings. Interchanging of numbered pieces is not permitted.

5.1.3 Slate stone shall be free of any ice or frost at time of installation. Salt shall not be used for the purpose of melting ice, frost, or snow on the stone pieces.

5.1.4 Adequate protection measures shall be taken to ensure that exposed surfaces of the stone shall be kept free of mortar at all times.

5.2 Mortar Setting and Anchorage

5.2.1 All setting shall be done by competent Stone Setters, in accordance with approved shop drawings.

5.2.2 Exterior panels shall be anchored to the masonry wall or framing by at least four bronze wire or other nonferrous metal anchors for each piece. Standard size anchor is 1/8" to ¼" wire (depending on the thickness of the stone) turned down 1" into a 3/8" round, 1½" deep hole in the edge of the slate. Each piece must be anchored individually for proper adjustment. Slabs over 12 square feet in surface area shall have at least two additional anchors every 6 square feet. Relief angles and liners may be required at normal floor-line distances.

5.2.3 The larger the panel, the more pronounced and rustic will be the textured face. Generous tolerance allowances of this natural-textured material will give more speed and ease in installation and a better general appearance. Anchoring and setting methods should allow for slight adjustments of each individual panel. Careful piece-to-piece selection should be exercised by the Slate Contractor at the job. Individual anchoring allows proper adjustment and alignment of each piece in relation to surrounding pieces. Round anchor holes in the edge of the slate to receive nonferrous wire anchors are the least expensive and the strongest system. Slots for strap anchors are sometimes acceptable.

5.2.4 Rear face of slabs should be at least 1" from the face of the backup wall. Gauged backs are frequently required where fitting is tight. Space between back of slate and wall should not be filled in completely, but instead spotted with approved nonstick mastic compound or portland cement in spots approximately 6" x 6" located every 18" apart. All shims and blocks must be removed.
Interior panels are set and anchored similarly to exterior work.

5.2.5 Panels set in metal frames shall have rabbeted edges and a sealant for all joints to prevent moisture seepage. Hairpin-spring anchors in the back of the panels make slate easily adaptable to slate-faced precast units and systems.

5.2.6 In some selected interior work, small 1'-0" x 1'-0" or less ¼" thick gauged panels can be applied with a proper adhesive without anchors. Some interior work may be set with narrow joints without grout.

5.2.7 Individually set thin slate tile (¼" or 3/8") on vertical surfaces exceeding 15'-0" is not recommended.

5.3 Mortar Joints

5.3.1 Mortar joints shall be raked out to a depth of ½" to ¾". Apply pointing mortar in layers not exceeding 3/8" and allow each layer to get hard to the touch before the next layer is applied. Tool finished joints with a concave tool having a diameter approximately 1/8" greater than the joint width.

5.3.2 Care shall be taken to keep expansion joints free of mortar, which would compromise their function.

5.4 Anchorage

5.4.1 All slate shall be anchored or doweled in accordance with the approved shop drawings.

5.4.2 To the furthest extent possible, all anchor preparations in the slate units shall be shop-applied.

5.4.3 All anchorage devices and anchor hole/slot fillers shall be in accordance with ASTM C1242. Care must be taken to ensure that any holes capable of retaining water are filled after use to prevent water collection and freezing.

5.5 Sealant Joints

5.5.1 Where so specified, joints requiring sealant shall be first filled with a closed-cell ethafoam rope backer rod. The backer rod shall be installed to a depth that provides optimum sealant profile after tooling.

5.5.2 If recommended by the Sealant Manufacturer, primers shall be applied to the substrate surfaces according to the manufacturer's directions prior to application of the joint sealant.

5.6 Expansion Joints

5.6.1 It is not the intent of this specification to make control or expansion joint recommendations for a specific project. The Specifying Authority must specify control or expansion joints and show location and details on drawings.

5.7 Caulking

5.7.1 Where so specified, joints shall be pointed with the sealant(s) specified in Section 2.4, after first installing the specified backup material and applying a primer if required, all in strict accordance with the printed instructions of the Sealant Manufacturer.

5.7.2 All sealants shall be tooled to ensure maximum adhesion to the contact surfaces.

5.8 Weep Tubes

5.8.1 Plastic or other weep tubes shall be placed in joints where moisture may accumulate within the wall, such as at base of cavity, continuous angles, flashing, etc., or as shown on architectural drawings.

6.0 CLEANING AND PROTECTION

6.1 Cleaning

6.1.1 The Slate Contractor shall keep the slate clean with a sponge and clean water. No mortar drippings shall be allowed to dry on the face of the slate. Upon completion of various portions of work, all mortar stains, grease marks, and dirt should be removed by washing with a good grade of cleaner. Flush and clean with clear water.

6.2 Protection of Finished Work

6.2.1 After the slate work has been installed, it shall be the responsibility of the General Contractor to see that it is properly and adequately protected from damage or stains until all trades are finished. This responsibility includes the stone cleaning costs prior to final inspection. The Slate Contractor will outline the needs for protection, in writing, to the General Contractor.

PRODUCT DESCRIPTION - Slate

1.0 GEOLOGICAL CLASSIFICATION

1.1 Slate is a fine-grained, metamorphic rock exhibiting "slaty" cleavage, which allows it to be split into thin sheets.[1] It is a low-grade metamorphic rock formed from shale, which is a thin-bedded, fine-grained, clastic sedimentary rock compacted from mud of clay-sized silicate clay minerals.[2]

1.2 How Slate Is Formed. Clay minerals are often suspended in the turbid waters of rivers, lakes, and ponds following heavy rains and their consequent flooding. When turbidity ceases, clay particles settle to the bottom of the still water, descending with a rocking, back-and-forth motion, like falling leaves. Over time, the clay accumulates in thin, flat layers on the bottom. Additional layers are deposited with each heavy rain or flood event until gradually many thin layers build up multiple beds of clay sequences with a water saturation of about 60%. If undisturbed through continual sedimentation, compaction occurs, squeezing out ±95% of the water. With increased burial to thousands of feet, additional compaction and cementation occurs, and shale is formed. Shale readily splits apart at bedding planes, sometimes into very thin sheets or thick units.

1.3 If the resulting shale sequence, a clastic sedimentary stone, is subjected to regional compression at a high enough pressure-temperature-time cycle, then metamorphism occurs. Regional pressure at this level usually folds the entire sedimentary sequence, thus the bedding surfaces will generally, but not always, be at some angle to the pressure. Pressure causes the small, flat sheets of clay minerals in the shale to always realign normal (perpendicular to the direction of pressure). The metamorphic pressure can be from any direction and may have no relation to former bedding, only coinciding with bedding as an accident of fold geometry.

1.4 This realignment and added compression develops the "slaty" cleavage or cleavability, one of the defining and most useful properties of slate. Because of the realignment of the microscopic sheets of clay minerals, the new cleavage is independent of the former bedding, which can no longer function as a parting plane even though it may still be perfectly visible as a color demarcation. A fresh cleavage surface on slate has a silvery sheen from the microscopic sheets of muscovite and chlorite mica that typically develop on cleavage surfaces in low-grade metamorphism. Time, oxidation, freezing and thawing, rain, and hail ultimately fade colors and degrade the stone's sheen. This is not a fault–just the normal consequence of weathering and not detrimental in most cases unless water penetrates to allow frost heaving.

1.5 Slate colors are caused by small amounts of iron (red-brown), organic carbon (black), and other additives, minerals, or mixtures that yield violet, green, gray, and other colors.

1.6 Slate quality has been commonly related to how long it lasts on a roof. Some slates from northern New England are known to endure at least 250 years. Slate roofs from Vermont dwellings constructed circa 1740 have been recycled to new homes and remain in good condition, exhibiting only some fading from surface oxidation of carbonaceous matter that once gave the slate its dark gray hue. Slate from areas of less intense metamorphism or slightly less optimal parent rock composition several states to the south of Vermont are reported to be good for 75 to 100 years.

1.7 Phyllite. If the metamorphic pressures are more intense, the time under pressure is

[1] Ref: American Geological Institute. *The Glossary of Geology*, 2nd ed., 1980, Bates and Jackson, eds.

[2] *Clay*, the word, has two distinct meanings: *Clay minerals* are complex silicates, the products of chemical weathering of feldspar and other silicate minerals. Clay minerals have a sheet-like molecular structure, the same structure as mica. Clay mineral sheets are carried in suspension by water, and deposition from suspension when turbidity ends. *Clay* is also a size term defined as particles less than 1/256 mm or 0.00016" in size. Particles can also be ground-up mineral crystals, rock fragments, and colloidal lithic material, as well as clay minerals.

longer, or the parent shale composition is silty, sandy, or contains other foreign matter and entrained chemicals, the resulting metamorphic stone may develop into phyllite, the next higher metamorphic grade. Phyllite tends to have nonuniform, undulating cleavage surfaces and often large cubes or crystals of pyrite (FeS_2) that quickly oxidize and bleed ugly iron stain, or superhard garnet "knots" that occur as lumps and bumps on the wavy cleavage. Phyllite develops more muscovite mica (a hydrous potassium aluminum silicate) and sericite (iron carbonate or $FeCO_3$) on the cleavages than slate, thus phyllite has an even more silky silver sheen than ordinary slate.

1.8 Schist. If the variables in metamorphism already mentioned are carried to the next step, then schist is developed. In schist, secondarily developed minerals from intense metamorphism such as muscovite or biotite mica occur in compact masses and usually do not have the well-defined, flat cleavage characteristic of slate, thus schist is unsuitable for most traditional uses of slate. The mica flakes do not lie in flat planes and are loose enough to easily flake off. Schist is named for the major, flat mineral in its composition; for example, muscovite schist, biotite schist, hornblende schist, etc.

1.9 Unfortunately, some schists and phyllites are sold as slate and when used in exterior applications result in sheets sloughing off, iron stains bleeding out of the stone, or actual disintegration of tiles and slabs. Some of these "marginal slates" are highly colored and have interesting textures, but are best reserved for interior, decorative applications and not in places where there is potential moisture or where falling stone is a safety hazard.

1.10 Because the metamorphic process and resulting stone is so dependent on the right combination of parent stone composition, location, and the pressure-temperature-time cycle, the products are a continuum from one extreme to another–from insufficiently metamorphosed to highly metamorphosed–both extremes being unsuitable for building purposes. A stone that cannot be used isn't "bad," but there is simply a lot of stone unsatisfactory for commercial applications.

2.0 COLOR AND VEINING

2.1 The color of a slate is determined by its chemical and mineralogical composition. The gray and bluish-gray colors are due chiefly to the presence of carbonaceous material; many other colors are due to iron compounds. Slates containing large proportions of finely divided carbonaceous matter are black. Other colors that are found are blue-black, red, green, purple, mottled, yellow, brown, and buff.

2.2 Permanence of color has considerable importance, for although some slates maintain their original color for many years, others change to new shades within a comparatively short time.

2.3 Some slates tend to fade under the influences of the elements. Such changes may be due to the presence of small quantities of iron-lime-magnesia carbonates which decompose readily and form a yellow hydrous iron oxide, limonite. Therefore, slates are of two types: unfading and fading. Unfading color is not a quality verifiable by any current ASTM or other test method.

3.0 TEXTURE

3.1 Differences in conditions of deposition often result in variations in texture of successive strata, and such variations make it possible to trace folds and contortions within the quarry. "Ribbons" are dark bands, a fraction of an inch to several inches in width, intersecting blocks of slate at various angles. Cleavage and grain are other characteristics of slate that can affect its texture. Cleavage is the tendency for stone split with ease in one direction. However, many slates have a second direction of splitting that is less pronounced called the grain.

4.0 FINISHES

4.1 Slate's surface may be finished in a number of ways. Typical finishes for slate are:

4.1.1 Natural Cleft: A cleavage face formed when the slate is split into any thickness.

4.1.2 Honed: A satin smooth surface with no gloss.

4.1.3 Sand Rubbed: A flat, nonreflective surface.

4.1.4 Tumbled: A weathered, aging finish.

4.1.5 Machine Gauged (Diamond Gauged): Surface is a level plane with swirl marks noticeable.

4.2 The type of finish desired bears some relationship to final cost, as the smoother surfaces require more finishing, and consequently, more time. The most economical finish is the natural cleft.

4.3 Other finishes, such as **bush-hammered**, **sandblasted**, and **planed**, may also be available. Some stone finishes can affect strength and durability. For example, bush-hammered and thermal finishes reduce a stone's thickness, making it more vulnerable to weakening from exposure to freeze and thaw cycles.

5.0 THICKNESS

5.1 Standard thicknesses for slate veneers are ¾", 1", 1¼", 1½", and 2". Slate tiles are available in a variety of thicknesses ranging from ¼" to 1". The following table represents approximate recommended thicknesses for selected slate applications:

Use	Thickness	
	Residential Foot Traffic	Commercial Foot Traffic
Flagging (exterior)	¾"	1"
Thresholds	¾" –7/8"	1" – 1 ¼"
Tile	¼" – 5/8"	¾" – 1"
Treads	1" – 1 ¼"	1 ½" – 2"

6.0 SIZES

6.1 Slate is a product of nature with many varieties available, each possessing varying characteristics. Little can be done to alter the condition in which nature presents these varieties to us. Therefore, size may become a limiting factor to consider in the selection of a particular slate. The following table represents approximate recommended sizes for selected slate applications.

Use	Length (max)	Width (max)
Flagging (exterior)	1"-6"	2'-0"
Thresholds	4'-0"	8"
Tile	2'-0"	1'-6"
Treads	5'-6"	1'-6"

6.2 A jointing scheme which permits the use of smaller sizes of slate will greatly facilitate selection and delivery. The MIA Member/Supplier can assist with approval of the final scheme.

7.0 PRODUCT SAMPLING

7.1 Slate is formed by nature; thus, there are variations in the tonal qualities of the stones. However, it is these natural variations that make slate unique, valuable, and highly desirable. Because of these variations, selection of a particular slate should never be made on the basis of one sample only. It is recommended that selection be based on viewing sufficient samples to show the complete range of colors of the desired stone. MIA Members can provide these range samples.

8.0 PROPER USAGE TIPS

8.1 Recommendation for commercial floors:

8.1.1 Minimum ¾" thickness.

8.1.2 A honed or cleft finish.

8.1.3 A minimum hardness value of 8 as measured by ASTM C241.

8.2 Avoid the use of gypsum or molding plaster setting spots for the installation of stone.

9.0 TOLERANCES

9.1 Because of the variances in natural cleft or cleavage, it is recommended that the Slate Quarrier or Fabricator be contacted regarding size and thickness tolerances.

10.0 SOUNDNESS

10.1 Slate, consisting as it does chiefly of very small overlapping flakes consolidated under pressure, is a strong rock. Most mica slates of good commercial quality are highly impervious to moisture.

TECHNICAL DATA - Slate

1.0 PROPERTIES OF SLATE DIMENSION STONE

1.1 In centuries past, relatively little importance was attached to the ultimate physical capabilities of most building materials. Rule of thumb was a common structural design criterion. As a result, the widely used materials of the day, for the most part natural rather than manmade materials, were seldom stressed to their ultimate limits.

1.2 In present-day construction, however, this is far from being true. Performance requirements are daily becoming more demanding. In striving for taller structures, greater spans, firmer foundations, thinner walls and floors, stronger frames, and generally more efficient buildings with more usable space, today's Architects and Engineers must get the most out of the materials with which they work.

1.3 Slate is a product of nature and not always subject to the rules of consistent behavior that may apply to manufactured building materials.

1.4 Physical property values of slate may, however, be measured using the standard test methods approved by the Dimension Stone Committee C-18 of ASTM International. The MIA and Member companies are represented on the ASTM committee and are active in its technical work of establishing proper test methods and specifications consistent with the latest technology.

1.5 Final design should always be based on specific values for the slate variety ultimately to be installed. These values may be obtained from the Slate Supplier. All materials are not suitable for all uses. In order to avoid mistaken selections, tests for material values should be made prior to final material selection.

1.6 Physical Properties of Slate.
(This historical data and information is provided only as a guideline. Recommended minimums or maximums are established and provided by ASTM International.)*

Property	Range of Values
Compressive Strength (C170) lbs/in²	10,000-15,000
Flexural Strength (C880) lbs/in²	6,000-5,000
Density, lb/ft³ (C97)	170-190

Property	Range of Values
Modulus of Rupture (C120) lbs/in²	5,500-9,000
Recommended (min): 7,200 along grain, 9,000 across grain	
Absorption, by Weight % (C121)	0.1-0.45
Recommended (max): 0.25 interior, 0.45 exterior	
Abrasion Resistance (C241) (H_a)	6.0-10.0
Recommended (min): 8	

* Test methods described in current ASTM standards.

2.0 STRENGTH (ASTM C120, C880)

2.1 Values for modulus of rupture and flexural strength are determined by testing specimens of slate under laboratory conditions until they fail.

2.2 The strength of slate is a measure of its ability to resist stresses. This strength depends on several factors: the amount of mica flakes and quartz grains present, the degree of cohesion, and the nature of any cementing materials present.

3.0 FIRE RESISTANCE

3.1 Slate is not combustible according to underwriters' ratings, and therefore is considered a fire-resistant material. Because of its thermal conductivity, heat transfer is fairly rapid. Most slate is not considered a highly rated thermal insulator.

3.2 Underwriters' fire-resistance ratings evaluate whether or not a material will burn, as well as how long it will keep surrounding combustible materials from reaching temperatures which will cause them to ignite. Methods of estimating fire-resistance periods of masonry walls and partitions utilizing component laminae are given in "Fire Resistance Classifications of Building Construction," BMS92, National Bureau of Standards.

4.0 ABRASION RESISTANCE (ASTM C241, C1353)

4.1 Abrasion resistance is a property of slate that should be tested per ASTM C241/ C1353 to provide an indication of the slate's wearing qualities when exposed to foot traffic.

4.2 The hardness and uniform wearing qualities of most slate makes it extremely desirable and economically practical for floors and stairs. Varieties with an abrasive hardness (Ha) of 8 or more as measured by ASTM C241/C1353 tests are recommended for use as flooring exposed to normal foot traffic. A minimum abrasive hardness of 10 is recommended for commercial floors, stair treads, and platforms subject to heavy foot traffic. The abrasion resistance hardness values pertain to foot traffic only. If floors are constructed with two or more stone varieties, the H_a values of the stones must not differ by more than 5 or the floor surface will not wear evenly and uniformly.

5.0 FACTORS AFFECTING PROPERTIES (ASTM C121, C217)

5.1 The ultimate test of a building material is its ability to have and maintain the necessary structural strength, as well as beauty of appearance and low cost of maintenance, over the useful life of the structure. Experience has proven that slate meets this test as few other building materials can. Studies have shown that the durability of most slates is little affected by cycles of weather. This is because of slate's low rate of water absorption.

5.2 Currently, two ASTM test methods are unique to slate. ASTM C217 "Standard Test Method for Weather Resistance of Slate," is a method that is useful in indicating the differences in weather resistance between various slates, and should be used to correlate their durability. ASTM C121 "Standard Test Method for Water Absorption of Slate," provides another element in the comparison of slates. Water absorption testing can be helpful in determining the porosity of a particular slate.

6.0 SAFETY FACTORS

6.1 Good engineering practice requires that allowable design stress must provide a margin of safety in any structural element. As a necessary precaution against such conditions as wind, ice, snow, impact, temperature changes, and imperfect workmanship, these allowable stresses must be smaller than those which produce failure.

6.2 Within the accepted limits of safe design practice, the closer the allowable load is to the ultimate failure load, the more efficient is the use of the material and the less the cost of the construction.

6.3 Contemporary building design does not usually employ slate as part of the structural frame, but rather as an independent unit, a curtain wall, or veneer. Therefore, the primary concern in such cases is with wind or seismic loads, and a safety factor of 5.0 is recommended. Where the slate is to be subjected to concentrated loading, such as stair treads or lintels supported only at the ends, a factor of 10.0 should be used. These safety factors may be adjusted using sound engineering principles and judgment.

6.4 As buildings become taller and individual slate slab veneer becomes larger in area, the lateral forces due to wind loads must be considered. Wind tunnel tests are often used on major structures to determine wind dynamics and force magnitude. Reinforcement is sometimes necessary for large-dimension slab veneer in critical areas.

7.0 SEISMIC CONSIDERATIONS

7.1 Seismic considerations generally require that low buildings be stiff, and that tall buildings be relatively flexible. Design of connections must account for seismically induced horizontal loading. Local building codes vary and must always be checked to determine specific requirements for each area. The National Bureau of Standards has published two documents on the topic: "Earthquake Resistant Masonry Construction," NBS Science Series 106; and "Abnormal Loading on Buildings and Progressive Collapse: An Annotated Bibliography," NBS Science Series 67. The U.S. Army Corps of Engineers has also published TM 5-809-10, "Seismic Design for Buildings."

8.0 EFFLORESCENCE AND STAINING

8.1 Efflorescence is a salt deposit, usually white in color that appears on exterior surfaces of masonry walls. The efflorescence-producing salts found in masonry are usually sulfates of sodium, potassium, magnesium, calcium, and iron. Salts which are chlorides of sodium, calcium, and potassium will sometimes appear, but they are so highly soluble in water that they will be washed off by rain.

8.2 The water-soluble salts causing efflorescence come from other materials in the wall. The salts exist in small amounts and are leached to the surface by water percolating through the walls. The most feasible means of prevention is to stop the entrance of large amounts of water. Absorption from the face will not cause efflorescence unless there are open joints.

8.3 Slate is seldom injured by efflorescence. However, some of the salt crystals may form in the pores near the surface. Crystal growth (recrystallization) in the pores can cause stress on the walls of the pores and cause the stone to flake off. If the conditions bringing about this action persist, scaling may continue and flake off one layer after another. For this to happen, large amounts of water must enter the wall and must contain large amounts of salts.

8.4 Calcium carbonate is the least resistant constituent of slates to long weather exposure, especially to sulfur fumes, for sulfur trioxide acting on calcium carbonate forms calcium sulfate, or gypsum, a mineral which expands greatly with disruptive effects during crystallization. Iron carbonate is sometimes present, and its decomposition not only affects the slate, but the resulting iron oxides may cause stains. Iron sulfides may oxidize and form spots and stains. The oxidation of iron-bearing minerals, especially ferrous carbonate, often causes color changes.

NOTES: