Granite

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GRANITE

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 C615, Standard Specification for Granite Dimension Stone

1.2.2.2 A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

1.2.2.3 B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

1.2.2.4 C97, Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone

1.2.2.5 C99, Standard Test Method for Modulus of Rupture of Dimension Stone

1.2.2.6 C119, Standard Terminology Relating to Dimension Stone

1.2.2.7 C170, Standard Test Method for Compressive Strength of Dimension Stone

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

1.2.2.9 C270, Standard Specification for Mortar for Unit Masonry

1.2.2.10 C295, Standard Guide for Petrographic Examination of Aggregates for Concrete

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

1.2.2.12 C1201, Standard Test Method for Structural Performance of Exterior Dimension Stone Cladding Systems by Uniform Static Air Pressure Difference

1.2.2.13 C1242, Standard Guide for Selection, Design, and Installation of Exterior Dimension Stone Anchors and Anchoring Systems

1.2.2.14 C1352, Standard Test Method for Flexural Modulus of Elasticity of Dimension Stone

1.2.2.15 C1353, Standard Test Method for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic Using a Rotary Platform Abraser

1.2.2.16 C1354, Standard Test Method for Strength of Individual Stone Anchorages in Dimension Stone

1.2.2.17 C1515, Standard Guide for Cleaning of Exterior Dimension Stone, Vertical and Horizontal Surfaces, New or Existing

1.2.2.18 C1528, Standard Guide for Selection of Dimension Stone for Exterior Use

1.2.2.19 C1721, Standard Guide for Petrographic Examination of Dimension Stone

1.2.2.20 C1722, Standard Guide for Repair and Restoration of Dimension Stone

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.

1.2.4 National Building Granite Quarries Association (NBGQA)

1.2.4.1 Specifications for Architectural Granite

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 granite 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, NBGQA, or ASTM International.

1.5 Source of Supply

1.5.1 All granite shall be obtained from quarries having adequate capacity and facilities to meet the specified requirements, and from 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 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 Granite Contractor shall submit through the General Contractor, for approval by the Specifying Authority, at least two sets of samples of the various kinds of granite specified. The sample size shall be 1'-0" x 1'-0" minimum and shall represent approximately the finish, texture, and anticipated range of colors to be supplied. One set of approved samples shall be retained by the Specifying Authority, and one set shall be returned to the Granite Supplier for record and guidance. It is noted herein that granite is a natural material and will have intrinsic variations in color, markings, and other characteristics. Depending on granite 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 Granite Contractor shall submit through the General Contractor, for approval by the Specifying Authority, sufficient sets of shop drawings, showing general layout, jointing, anchoring, stone thickness, and other pertinent information. These drawings shall show all bedding, bonding, jointing, and anchoring details along with the net piece dimensions of each granite 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 Granite Contractor for fabrication. NO FABRICATION OF GRANITE SHALL BE STARTED UNTIL SUCH DRAWINGS HAVE BEEN FULLY APPROVED AND MARKED AS SUCH. The Granite 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; or (4) the types, sizes, or locations of anchors, unless specifically added to the scope of work.

1.8 Defective Work

1.8.1 Any piece of granite 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.

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 Granite

2.1.1 General: All granite 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 within the range of samples approved by the Specifying Authority.

2.1.1.2 ASTM C615 [C97] [C99] [C170] [C241] [C880] See the chart of applicable ASTM standards and tests in the Appendix.

2.1.2 Schedule: Granite shall be provided as follows:

2.1.2.1 For (*state location on building*) (*state name and color*) granite with a (*type*) finish, supplied by (*name company or list several approved suppliers*).

2.1.2.2 Provide information as in (1) for each different granite/finish combination in the project.

2.1.3 Finishes: Finishes listed in the schedule shall conform with definitions by MIA, NBGQA, or ASTM International.

2.2 Setting Mortar

2.2.1 Mortar for setting 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.

2.3 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 sealing of joints. The backup material used with the sealant shall be (*identify material*).

2.5 Anchors, Cramps, and Dowels

2.5.1 All anchorage components shall be of 300 Series stainless steel (refer to ASTM A666) or aluminum (refer to ASTM B221) with strength and durability properties meeting or exceeding those of 6063-T6. Anchor types and assemblies shall comply with ASTM C1242. Reliance on adhesives alone for material attachment will not be permitted.

3.0 FABRICATION

3.1 Beds and Joints

3.1.1 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 Backs of Pieces

3.2.1 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.

3.3 Moldings, Washes, and Drips

3.3.1 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.

3.4 Back-checking and Fitting to Structure or Frame

3.4.1 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.

3.4.2 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.)

3.5 Cutting for Anchoring, Supporting, and Lifting Devices

3.5.1 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 may be drilled at job site by Granite Contractor to facilitate alignment.

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

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

3.6 Cutting and Drilling for Other Trades

3.6.1 Any miscellaneous cutting and drilling of stone necessary to accommodate other trades will be done by the Granite 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 Granite Contractor.

3.6.2 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 Granite Contractor with the Granite Fabricator.

3.7 Carving and Models

3.7.1 All carving shall be done by skilled Stone Carvers in a correct and artistic manner, in strict accordance with the spirit and intent of the approved shop drawing, or from models furnished or approved by the Specifying Authority.

4.0 SHIPPING AND HANDLING

4.1 Packing and Loading

4.1.1 Finished granite 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. (See "6.2 Protection of Finished Work" in this chapter.)

4.2 Site Storage

4.2.1 Upon receipt at the building site, stone 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 granite 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 granite. If storage is to be prolonged, polyethylene or other suitable, nonstaining film shall be placed between any wood and finished surfaces of the granite.

4.2.2 Any holes or slots in the granite which are capable of collecting water shall be temporarily covered or plugged to prevent freezing of collected water. Such covers or plugs are to be removed immediately prior to installation of the piece.

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 granite 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 Granite 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 granite pieces. 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 of Granite

5.2.1 Clean base materials to remove dirt or other foreign matter.

5.2.2 Saturate concrete substrate several hours prior to setting granite. Prepare and place mortar in accordance with ASTM C270. Thoroughly wet stones prior to setting in mortar bed. Apply neat cement parge of approximate 1/16" thickness to granite units prior to placing on mortar bed. Tamp stones into place using a rubber or plastic mallet to obtain full contact with the setting bed and proper stone unit alignment.

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 granite shall be anchored in accordance with the approved shop drawings.

5.4.2 To the furthest extent possible, all anchor preparations in granite 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 locations 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 Granite shall be cleaned after installation and all pointing or caulking is complete. All dirt, excess mortar, weld splatter, stains, and other defacements shall be removed.

6.1.2 All cleaning methods shall be in accordance with ASTM C1515.

6.2 Protection of Finished Work

6.2.1 Granite installation in progress shall be protected with film or fabric tarps secured over the work.

6.2.2 After the granite is installed, it shall be the responsibility of the General Contractor to properly and adequately protect it from damage until all trades are finished. This responsibility includes the stone cleaning costs prior to the required final inspection. Where lumber is required for protection, care should be taken to protect the granite from staining by the lumber, using plastic film or other suitable materials. Any fasteners used in construction of temporary protection fixtures shall be corrosion resistant.

6.2.3 Finishes commonly available are defined as follows:

6.2.3.1 Polished: Mirror gloss, with sharp reflections.

6.2.3.2 Honed: Dull sheen, without reflections.

6.2.3.3 Fine Rubbed: Smooth and free from scratches; no sheen.

6.2.3.4 Rubbed: Plain surface with occasional slight "trails" or scratches.

6.2.3.5 Shot Ground: Plain surface with pronounced circular markings or "trails" having no regular pattern.

6.2.3.6 Thermal (Flamed): Finish produced by application of high-temperature flame to the surface. Large surfaces may have shadow lines caused by overlapping of the torch. This finish will vary in texture and depth between different types of granite, as the finish is largely dependent upon the granite structure of the stone.

6.2.3.7 Sandblasted, Coarse Stippled: Coarse plain surface produced by blasting with an abrasive; coarseness varies with type of preparatory finish and grain structure of the granite.

6.2.3.8 Sandblasted, Fine Stippled: Plain surface, slightly pebbled, with occasional slight "trails" or scratches.

6.2.3.9 Bush-hammered, 8-cut: Fine bush-hammered finish, interrupted by parallel markings not over 3/32" apart. A corrugated finish, smoother near arris lines and on small surfaces.

6.2.3.10 Bush-hammered, 6-cut: Medium bush-hammered finish, similar to but coarser than 8-cut, with markings not more than 1/8" apart.

6.2.3.11 Bush-hammered, 4-cut: Coarse bush-hammered finish with same characteristics as 6-cut, but with markings not more than 7/32" apart.

6.2.3.12 Sawn: Relatively plain surface with texture ranging from wire sawn (a close approximation of a rubbed finish), to shot sawn, with scorings 3/32" in depth. Gang saws produce parallel scorings; rotary or circular saws make circular scorings. Shot-sawn surfaces should be cleaned to remove all rust stains.

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

6.2.3.14 Rock (pitch) Faced: Similar to split faced, except that the face of the stone is pitched to a given line and plane producing a bold appearance rather than the comparatively straight face obtained in split face.

6.2.3.15 Jet Washed: After certain treatment finishes on stone, such as flaming, a high pressure jet wash can be used to assist in cleaning the stone and bringing back more color to the stone. Some producers have the machinery to use high pressure water with additives which gives a jet washed finish that looks like a flamed finish, yet maintains the color in the stone.

6.2.4 Minimum Thickness: The suggested minimum thickness for all exterior veneer is as follows:

6.2.4.1 Percussion produced finishes, such as **bush-hammered** (sometimes referred to as a **pointed finish**), require a 1¼" thick slab minimum to apply.

6.2.4.2 Other finishes can usually be applied to any thickness slab, with the exception of some granites not being able to withstand thermal finishing processes in thicknesses less than 1¼".

6.2.4.3 Determination of proper stone thickness must be evaluated using the following criteria:

- Piece Size.
- Final Face Finish.
- Anchoring Detail.
- Structural Design Load Requirements.
- Flexural Strength of the Granite.

6.2.5 Minimum safety factors of 3 to 1 minimum on granite flexural stresses and 4 to 1 minimum on anchorage components in granite are recommended.

6.2.6 Ashlar or veneer used as a facing requires a setting space of at least 1", as measured from the nominal thickness of the piece.

6.2.7 Bed and Joint Width. The minimum recommended bed and joint width is ¼" for exteriors and 1/8" for interiors.

6.2.8 Sawn backs. Because of physical characteristics, most granites cannot be split to a thickness less than 1/3 of the lesser face dimension. Consequently, sawn backs (see 3.4 in this chapter) should be specified for most veneers, and are frequently specified also for thicker ashlar, because of design considerations.

6.2.9 Staining. Granite should be protected from wet (green) wood, oils, mud, construction waste, and asphalt compounds. Contact Fabricator or Granite Contractor for proper remedies to staining problems that occur.

PRODUCT DESCRIPTION – Granite

1.0 GEOLOGICAL CLASSIFICATION

1.1 The American Geological Institute (AGI) defines granite as an intrusive igneous rock (cooled slowly in the deep upper part of the Earth's crust) composed of 25% to 35% quartz and over 50% potassium- and sodium-rich feldspars, with a common accessory mineral of less than 20%, usually muscovite (clear mica), biotite (dark, iron-bearing mica), or hornblende (amphibole).

1.2 The commercial stone industry, depending on the supplier or organization, loosely accepts various granite-like stones under the label of "granite." These include, among others, banded or massive, nonbanded gneiss, and a few quartz-based stones. Such stones are marketed as "granitelike" or "granitoid," though they are not true granite.[1] Gneisses, high level metamorphic stone, are included in the granite category by commercial interests.

1.3 The quartz-based stones are definitely not granite, but rather the silica-cemented sedimentary stone quartzite or its metamorphic equivalent, orthoquartzite. Quartzite, and especially orthoquartzite, have a distinct cleft or cleavage at a mica-rich parting. Knowing the difference between true granite and granitelike stone helps the stone industry professional to understand the physical properties, performance, and ultimately, the comparative quality of these natural materials.

1.4 Granite, as defined by the AGI, usually has three to four basic mineral components:

1.4.1 Quartz (SiO_2 ±25-35%), appears as irregular, watery-looking, or translucent grains.

1.4.2 Orthoclase Feldspar ($KAlSi_3O_8$ ≈20-80%). In most, but not all, commercial, geologic granites, the light-colored minerals, white- to flesh-colored are orthoclase feldspar.

1.4.3 Plagioclase Feldspar ($NaAlSi_3O_8$ to $CaAl_2Si_3O_8$ ≈20-80%) features darker gray to bluish grains, with some grains exhibiting fine, grooved lines and/or an iridescent sheen. Sometimes the mineral is a light, creamy color, nearly indistinguishable from orthoclase, except for the occasional presence of the fine lines.

[1] The following terms are derivations of the word *granite*, which are now obsolete because their definitions have become obscured and imprecise: *granide, granilite, granitelle, granitello, granitine, and granolite*. The use of these terms commercially is not recommended.

1.4.4 Dark accessory minerals (→20%) biotite and hornblende are complex silicates with all the elements in quartz, orthoclase feldspar, and plagioclase feldspar, plus iron and magnesium, which gives these minerals their dark color. Magnetite (Fe_3O_2) is often a trace mineral (±2-4%) in granite, and easily recognized by its strongly magnetic property. It, too, is black and opaque. Magnetite has a hardness rating of H=6, polishes well, has a metallic appearance, and is opaque (i.e., it does not transmit light even when very thin).

1.4.5 All of these granitic minerals have a Mohs Scale[2] hardness rating of H=7 or H=6 with the exception of biotite, which has a variable hardness of 2.5 to 4.5, depending on the angle of the polished surface in relation to the edges of the "books" of sheets that biotite mica crystals exhibit. Thus, biotite does not polish well and appears as small, rough spots on a polished surface. This is not a flaw in either the stone or polishing, but simply the way biotite is—softer than all other minerals in granite. Biotite hardness makes little difference in most applications, as the overwhelmingly dominant feldspar and quartz minerals are much harder. Biotite "plucks" slightly in polishing, but generally not when in use.

1.5 Granitization. Earth scientists came to realize that much granite is associated with metamorphic stone of extremely high levels. These are often **massive, nonbanded granites** with no noticeable mineral segregation into bands. Many examples come from, but are not limited to, some Far Eastern locations and Sri Lanka. These often have a strong presence of **red garnet**[3], a mineral indicative of metamorphism. Geologic granite, in terms of mineral content, can be formed by **granitization**, a true metamorphic process by which a solid rock is converted to granite by entry and/or exit of material or change of chemical components without going through a liquid or molten state.

1.6 Gneiss, a true metamorphic stone that exhibits strong mineral segregation in the form of contorted bands indicating metamorphic origin, is universally included in the granite group by the stone industry. **Banded gneiss** is a classical rock end member of the metamorphic process of high pressure, time, temperature, and the presence of fluids that begins with the sedimentary rock shale and proceeds through slate, to phyllite, then schist and finally, banded gneiss—from low to high levels of metamorphic rank.

2.0 COLOR AND VEINING

2.1 The color of a granite is governed largely by that of the feldspar, usually the most abundant mineral. However, it may be modified to some extent by the quartz, hornblende, or mica, if considerable amounts are present. Almost white, light gray, dark gray, green, pink, and red granites are common. Uniform color distribution is usually a desirable feature. Lighter-colored granites are the average composition of continental crust, while darker granites are more likely associated with or influenced by nearby oceanic composition stone.

2.2 Dark, granular igneous rocks, classified petrographically as anorthosite, basalt, diabase, diorite, and gabbro, are also used as dimension stone, and are classed commercially as "black granite."

[2] See Appendix for information about the Mohs Scale of mineral hardness.

[3] Garnet is most often noticeable when red, but also occurs in light green and light yellow.

3.0 TEXTURE

3.1 The term "texture," as applied to granite, means size, degree of uniformity, and arrangement of constituent minerals.

3.2 The texture of granite is determined by the size and arrangement of mineral grains. Uniform grain size usually is demanded in commercial granites. Grain size varies greatly in different types of granite.

3.3 Uniform distribution of the minerals is as important as uniform grain size. Light and dark minerals should be distributed evenly throughout the rock mass, for this gives uniform color and texture. Many commercial deposits display remarkable homogeneity; the rock may not vary in color or texture for many feet, either vertically or horizontally.

4.0 FINISHES

4.1 Granite surfaces may be finished in a number of ways. See the listing of typical finishes on page 5-7 of this chapter.

5.0 THICKNESS

5.1 Standard nominal thicknesses for granite are generally 3/8", ¾", 1¼", 1½", 2", 3", 4", 6", and 8".

6.0 SIZES

6.1 Granite is a product of nature with hundreds of varieties available, each possessing unique 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 granite.

6.2 A jointing scheme that permits the use of smaller sizes of granite will greatly facilitate selection and delivery. The MIA Member/Supplier should assist in final approval.

7.0 PRODUCT SAMPLING

7.1 Granites are formed by nature; thus there are variations in the tonal qualities of the stones. However, it is these natural differences that make granites unique, valuable, and highly desirable. Because of these variations, selection of a granite 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 finish.

8.1.3 A minimum hardness value of 25 as measured by ASTM C241.

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

9.0 VENEER CUTTING

9.1 Quarry blocks are reduced to slabs by a gang saw or wire saw. The gang saw consists of a series of steel blades set parallel in a frame that moves forward and backward. They are fed a cutting abrasive in a stream of water.

TECHNICAL DATA – Granite

1.0 PROPERTIES OF GRANITE 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, 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 Granite 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 stone may, however, be measured using the standard test methods approved by the Dimension Stone Committee C18 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 stone variety ultimately to be installed. These values may be obtained from the Stone 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 Granite

(This historical data and information are provided only as a guideline. Recommended minimums or maximums are established and provided by ASTM International.)*

<u>**Property**</u>	<u>**Range of Values**</u>
Compressive Strength (C170) lbs/in²	4,700-60,000
Recommended (min): 19,000	
Flexural Strength (C880) lbs/in²	700-5,500
Recommended (min): 1,200	
Modulus of Elasticity (C1352)** (in millions) lbs/in²	2.0-10.0
Density (C97), lb/ft^3	150-200
Recommended (min): 160	
Coefficient of Thermal Expansion, in/in/°F	4.7 x 10^{-6} average
Modulus of Rupture (C99) lbs/in²	1,000-3,000
Recommended (min): 1,500	
Absorption % (by weight)	0.02-0.40
Recommended (max): 0.40	
Abrasion Resistance H_a	20-90
Recommended (min): 25	

* Test methods described in current ASTM standards.

** Also known as Young's Modulus.

2.0 STRENGTH (ASTM C99, C170, C880)

2.1 Values for modulus of rupture, compressive strength, and flexural strength are ascertained by testing specimens of granite under laboratory conditions until they fail.

The C170 procedure is used for determining the compressive strength of a granite specimen. A cube or cylinder of 2" to 3" in all dimensions is crushed under a hydraulic ram and the compressive strength is calculated as the total load divided by the area of the specimen. Compressive strength of granite is seldom a factor in design, as the compressive strength is many times the anticipated compressive stresses. This value is most often used for comparison of stone types or as a general strength benchmark for the material.

2.2 The C99 and C880 procedures are both used for determining bending strength. The C99 procedure is much older, and the test protocol is seldom modified, so data obtained from this test has some value for comparison to historical data or between different stone types. As a measure of resistance to bending loads, it is not considered to be a representative modeling of panel behaviors in building applications. The ratio of beam length to beam depth is very small, resulting in what is referred to as "thick beam behavior." The results of this test are usually artificially high due to the thick beam behavior and high shear stresses in the loaded specimen

2.3 The C880 procedure is much preferred when testing granite for resistance to bending stresses. The procedure calls for a span-to-depth ratio of 10:1, which eliminates the influence of thick beam behavior. Furthermore, the test allows specimen modification to allow the use of actual building cladding thickness and actual finish, which provides a better representation of the stone behavior in the cladding application. This procedure also uses a four-point bending fixture, which provides a constant stress region over approximately 50% of the specimen. This provides a greater chance that the weakest point of the specimen will fall within this region and produce more reliable data for design use.

3.0 FIRE RESISTANCE

3.1 Stone 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 stone 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 that 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)

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

4.2 The hardness and uniform wearing qualities of most granites make them extremely desirable and economically practical for floors and stairs. Varieties with an abrasive hardness (Ha) of 25 or more, as measured by ASTM C241 tests, are recommended for use as flooring subject to normal foot traffic.

5.0 FACTORS AFFECTING PROPERTIES

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 stone meets this test as few other building materials can. Studies have shown that the durability of most stones is little affected by cycles of weather. This is because most have a low rate of moisture absorption.

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 that produce failure.

6.2 Within the accepted limits of safe design practice, the closer the allowable load is to the ultimate failure load in a structure, 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 granite 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. Safety factors of 3.0 for the granite and 4.0 for anchorage assemblies are recommended. Where the stone is to be subjected to concentrated loading, such as stair treads or lintels supported only at the ends, a factor of 4.0 or greater should be used.

6.4 These safety factors may be adjusted using sound engineering principles and judgment.

6.5 As buildings become taller and individual stone 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.

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, which 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 that 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 wall. 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 Some of the salt crystals may form in the stone's 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 contain large amounts of salts.

8.4 Research indicates that staining and discoloration occurring on new buildings are caused by the action of water percolating through concrete, from which soluble alkali salts are leached. The salts are then carried by the water through the stone, where partially oxidized organic matter is picked up. This is then transported to the surface of the stone, where it is deposited as a stain as the water evaporates.

8.5 This staining phenomenon is similar to efflorescence, except that it involves organic material. It does not harm the stone, other than leaving an objectionable appearance during or soon after erection. However, if left alone, the stain is removed naturally by the action of the elements, usually in the course of a few months.

8.6 Granite is one of the most durable of all building materials because the quartz and feldspar in it are highly resistant to normal weathering. Feldspars will, however, disintegrate slowly if exposed to an acid-bearing atmosphere, as in regions where hydro-carbons are prevalent. All granites disintegrate very slowly under repeated contraction and expansion due to diurnal and seasonal temperature changes, but under ordinary atmospheric conditions, granite will endure for years without significant change in color or durability.

9.0 PITTING IN GRANITE

9.1 Granites are made up of several different minerals, each having a different hardness. They can contain feldspars, biotites, amphiboles, ferrous titanium oxides, and other mineral combinations. For comparison, on the Mohs Scale, diamonds are the hardest substance, with a hardness of 10. By comparison, feldspars have a hardness of 6.5 to 7, which is still quite hard and durable. Biotites, the black minerals throughout the slab, are by contrast very soft (2.5 to 4.5) and flake easily. All true granites have biotite in their composition. Because biotites are soft and flaky, the first few layers are removed during the polishing process, causing pits. Some granites have more biotites throughout their composition than others. The higher the biotite content of the stone, the more pits it will have. All polished igneous/metamorphic rock will have varying degrees of pits, depending on the amount of biotites, muscovite, and phlogopite.

9.2 Pitting does not make the granite less durable or of inferior quality. Pits exist in all granites and should be expected when dealing with a natural, polished stone containing several types of minerals with different hardnesses.

10.0 BACTERIA

10.1 Bacteria requires several things in order to thrive and grow: oxygen, water, sunlight, nutrients, and a substrate to form on. The minerals in granite are toxic to bacteria. As a result, there is no habitable environment for the bacteria to live and grow on a granite surface.

11.0 RADON AND GRANITE

11.1 **Radon** is a naturally occurring gas generated by the decay of trace amounts of uranium found in the Earth's crust. It is an unstable gas that quickly breaks down and dissipates in the air.

11.2 Radon is measured in units called picocuries per liter (pCi/l). A picocurie is one trillionth (10^{-12}) of a curie, which is the amount of radioactivity emitted by a gram of radium. The U.S. Environmental Protection Agency has established 4 pCi/l as the standard for indoor air; 20 pCi/l represents the maximum amount of exposure to radium that is now allowed by U.S. regulations.

11.3 **Measurements of Radon from Granite Countertops.** "Over 500 measurements of radon emissions from granite have been published in the peer reviewed scientific literature.[4]" This study and other radon and radiation information and test results may be found at http://www.marble-institute.com/radon/. None of the research found a single stone that would be a health risk to homeowners.

[4] Natural Stone Countertops and Radon, 2008. Environmental Health & Engineering, publisher.

12.0 CAUTION ABOUT ENHANCED GRANITE

12.1 Several methodologies are being used to enhance varieties of granite. Caution, in some cases avoidance, should be exercised for the following methodologies:

12.1.1 Tinting. The adding of color dyes in sealer-type products to make the color of the stone conform to a more pleasing one. This is a short term "fix," as the color will bleed out from the stone when it is exposed to the sun, or is otherwise used.

12.1.2 Epoxy (polyester) Filling. Several varieties of over-burdened stones that do not meet the ASTM criteria for Granite Dimension Stone are being filled with epoxy or polyester resins (similar to the typical filling techniques employed in travertine) and marketed for a variety of uses. This type of stone is generally not suitable for wet or exterior applications.

12.1.3 Resin filling. This process is being performed to reduce the effects of "pits" in granite. Once treated, these stones are required to be marketed as "filled." Verify with the Producer and the End User that the type of fill being used is both safe and acceptable for the application intended.

NOTES:

