Designation: C1528 – 08

Standard Guide for Selection of Dimension Stone for Exterior Use[1]

This standard is issued under the fixed designation C1528; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Natural stone, while being perhaps the oldest building material known to man, can also be one of the most difficult of all building materials to properly evaluate, select, and specify. Every natural stone product is unique, having its own physical properties and performance capabilities. Responsible stone selection involves extensive and objective evaluation of both the stone material and the application in which it is required to perform.

This guide presents a cursory review of the different stone types commonly used in construction, common applications, available finishes, and factors affecting product costs. It is intended to be used in combination with good judgment, responsible engineering analysis, local building codes, and any other available resources. It is not a "how-to" or a "step-by-step" guide, and has been prepared with the assumption that the user has some familiarity in the use of natural stone prior to utilizing this guide.

Past performance is the best test of a dimension stone's durability. Yet because the physical properties of a natural stone can vary within a single deposit, even stones with a history of satisfactory performance may need to be tested to ascertain the quality of the current production stock. Common physical property tests include absorption, density, compressive strength, modulus of rupture, flexural strength, abrasion resistance, and anchor strength. Additional tests may also be required depending on the material and application.

In a high proportion of the cases, failure of a natural stone in service is a result of improper application, rather than the inherent properties of the stone. Placing stones in unsuitable environments, faulty fabrication, installation, or construction practices, and incompatible associated materials are frequent causes of stone system failures (for example, high-porosity stones in subgrade applications, inadequate anchorage or expansion space, mortars leaching alkalis, inappropriate strength mortars, staining grouts, voids in setting beds, and pavement stones with inadequate resistance to abrasion).

In selection of natural dimension stone products, the application as well as the aesthetic appeal must be considered. While aesthetics are important to the design, the selection of the proper stone material, thickness, anchorage, and related components is necessary to ensure meeting the performance and durability requirements of the design.

1. Scope

1.1 This guide is intended to be used by architects, engineers, specifiers, contractors, and material suppliers who design, select, specify, install, purchase, fabricate, or supply natural stone products for construction applications.

1.2 *Consensus Standard*—This guide is an industry consensus standard drafted in a cooperative effort among engineers, architects, geologists, producers, and installers of natural stone.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

C99 Test Method for Modulus of Rupture of Dimension Stone

C119 Terminology Relating to Dimension Stone

C120 Test Methods of Flexure Testing of Slate (Breaking

[1] This guide is under the jurisdiction of ASTM Committee C18 on Dimension Stone and is the direct responsibility of Subcommittee C18.08 on Selection of Exterior Dimension Stone.

Current edition approved May 15, 2008. Published July 2008. DOI: 10.1520/C1528-08.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Load, Modulus of Rupture, Modulus of Elasticity)
C121 Test Method for Water Absorption of Slate
C170 Test Method for Compressive Strength of Dimension Stone
C217 Test Method for Weather Resistance of Slate
C241 Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic
C503 Specification for Marble Dimension Stone
C568 Specification for Limestone Dimension Stone
C615 Specification for Granite Dimension Stone
C880 Test Method for Flexural Strength of Dimension Stone
C1201 Test Method for Structural Performance of Exterior Dimension Stone Cladding Systems by Uniform Static Air Pressure Difference
C1242 Guide for Selection, Design, and Installation of Dimension Stone Anchoring Systems
C1352 Test Method for Flexural Modulus of Elasticity of Dimension Stone
C1353 Test Method Using the Taber Abraser for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic
C1354 Test Method for Strength of Individual Stone Anchorages in Dimension Stone

2.2 Provisions of dimension stone handbooks, manuals, and specifications should be reviewed for compatibility with the principles outlined in this guide.

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, refer to Terminology C119.

4. Significance and Use

4.1 *Related Components*—Natural stone is only one component of a building's construction. All related materials and assemblies need to be evaluated to ensure compatible interactive behavior with the stone product.

4.2 *Applicable Codes*—Every stone application shall comply with applicable building codes.

EXTERIOR APPLICATIONS OF DIMENSION STONES

5. Introduction

5.1 Natural stones have long been used and admired for their beauty and permanence. As a natural material, each piece of stone has features and physical characteristics that make it unique. The rich variation in color and texture, as well as its ability to age gracefully in the exterior environment, has made stone one of the most popular materials for construction, sculpture, and monuments.

5.2 Varieties of stone possess certain properties making it suitable for a specific application. Stone geology (mineral content and structure), compressive strength, flexural strength, resistance to absorption and erosion, as well as its ability to be worked, vary widely by stone type. These are all key characteristics that dictate the best use of the material and must be considered during the process of stone selection.

6. Exterior Applications

6.1 This guide is limited to the discussion of exterior applications of stone. Of these, there are several major categories, which are introduced briefly as follows:

7. Load-Bearing Masonry

7.1 Load-bearing masonry is perhaps the oldest form of stone construction. Its defining feature is the transferring of structural load vertically by relying on the compressive strength of the stone to support itself and other imposed loads. Due to the weight of the stone itself, structures built in this manner tend to be of limited height. As the height of the structure increases, the wall thickness at the structure's base must increase, thus requiring large individual stones, or multiple wythes of stone. The costs of such walls are typically higher than other systems, due to the large amount of stone and labor involved.

8. Cladding

8.1 In response to the limitations and expense of load-bearing masonry, stone cladding systems were developed. Cladding systems can offer the appearance of load-bearing masonry but without the mass and expense. Cladding systems also offer a wide variety of applications, allowing greater architectural innovation.

8.2 When stone is used as cladding, it is exposed to unique loading characteristics that can require complex structural analysis and detailing in order to be used successfully. Materials other than stone are also often integrated into cladding systems, requiring consideration of their material properties as well as compatibility with the stone components.

9. Building Trim

9.1 Stone has been and continues to be used in architecture to accent other building materials, or to perform a specific purpose. Stone is often integrated into wall systems as decorative belt courses, window sills, lintels, arches, or water tables. Stone can add an element of interest to buildings, in addition to performing as a durable wall component with a specific and well-defined purpose.

10. Pavements

10.1 From cobblestone streets to modern plazas, stone is used to carry vehicle and pedestrian traffic. Modern systems include those bearing on pedestals and traditional sand or cement-based setting bed systems.

10.2 Materials used for steps must have a high resistance to abrasion and provide a surface with adequate slip resistance for public safety. Many varieties of dimension stones, with appropriate finish, will satisfy both of these requirements.

11. Steps

11.1 Materials used for steps must have a high resistance to abrasion and provide a surface with adequate slip resistance for public safety. Many varieties of dimension stones, with appropriate finish, will satisfy both of these requirements.

11.2 Steps are manufactured from dimension stones as "cubic," in which the tread and riser faces are of one piece of

stone, and also "veneered" in which multiple pieces of thin stone material are placed over a concrete or steel frame to form the tread and riser surfaces.

12. Coping

12.1 Wall systems that are fully exposed to the environment, such as roof parapet walls, balcony and terrace enclosure walls, and planter walls, are particularly susceptible to water penetration. Stone coping and wall caps are often used to help protect the underlying wall system from excessive moisture penetration and associated distress.

12.2 Copings and wall caps can also add a visual accent to the wall system, improving the appearance of the wall system by defining changes in the wall configuration.

12.3 Stone copings and wall caps are typically jointed, therefore, protection of the wall system is also reliant on proper treatment of the joints.

13. Roofing

13.1 Roofing applications for natural stone are typically limited to slate, a variety of stone that can be quarried and fabricated into thin, shingle-shaped elements. Dense, nonporous stones can provide a durable, water-resistant roof system that effectively utilizes the unique physical characteristics of the material.

14. Ornamental, Sculpture, and Monumental Elements

14.1 Many varieties of stone possess characteristics that make them a desirable material for sculpting and carving. Most stone varieties can be worked by hand or power tools into unique shapes and representations, including engravings and reliefs. Properly selected stones can demonstrate resistance to environmental effects, thereby providing a sense of permanence to monuments and decorative sculpted items.

COMMON DIMENSION STONE TYPES—GRANITE

15. Mineralogy, Appearance, and Texture

15.1 The term "granite" has both geological and commercial definitions. There are many rock types that are not classified as granites by true geological definition, yet they are included in the commercial classification of granite because they exhibit similar performance and behavioral characteristics as true granites. For the purpose of this guide, "granite" is used in its commercial sense. This includes any visibly granular, igneous rock consisting mostly of feldspars and quartz accompanied by one or more dark minerals.

15.2 Typically, feldspar is the most abundant mineral found in granites, and because of this, the color of the granite is largely governed by the color of this mineral. The color can be modified by the quartz, hornblende, mica or any other mineral present in significant quantity. Dark granular igneous rocks, classified petrographically as anorthosite, basalt, diabase, diorite, or gabbro, are often referred to as "black granites." Using the rather broad commercial definition of granite, granites are available in a wide array of colors including pink, gray, white, red, black, brown, buff, green, and blue.

15.3 The majority of granites found in the industry are granular or crystalline in appearance, with the grain size varying anywhere between 2 or 3 mm up to 25 mm or larger. Some of the materials included in this definition will show a layered or plate-like structure due to recrystallization, folding, or other changes while the rock was in a plastic or semi-molten state. Such metamorphic rocks are called granite gneisses.

15.4 A granite with uniform distribution of the minerals is desirable for the supply of a large application with minimal color variation. Many commercial deposits exhibit remarkable homogeneity across vertical and lateral distances, while other deposits will display considerable variation between adjacent blocks or even within one block.

15.5 Many granites are "anisotropic," or "directionally specific" in either appearance or performance, and as such, dictate attention to the direction that they are quarried and sawn to achieve the desired visual and performance requirements. Other granites are nearly "isotropic," with similar appearance and performance characteristics regardless of the direction the material is cut.

16. Suitability for Use

16.1 Granite materials have one of the widest ranges of applications of any natural stone type. Architectural use of granite includes exterior and interior cladding, exterior and interior paving, furniture tops, and landscape applications such as curbs, retaining walls, or copings. Granite is frequently used in monument or memorial applications where permanence and weather resistance are primary considerations. The chemical resistance and dimensional stability of granite allow limited industrial applications such as pickling tanks, surface plates, precision machine bases, and paper machine press-rolls.

16.2 The particular finish specified for the granite may have a greater bearing on its suitability for use than the granite itself. Polished and honed finishes are popular for vertical surfaces because of their refined appearance and low maintenance requirements. These finishes are not recommended for walking surfaces as they have relatively poor slip resistance. Textured surfaces such as thermal, tooled, or sanded are commonly used in pedestrian traffic areas due to their favorable frictional properties.

16.3 *Physical Strength*—Physical strength properties of granite are determined by laboratory testing in accordance with ASTM standard test procedures for each physical property to be evaluated. Minimum or maximum values for each physical property, to aid in determination of a specific granite's suitability for exterior exposure, are in accordance with Specification C615.

17. Standard Thicknesses

17.1 Most granite products are custom made to the designer's specifications. The slab thickness however, is best kept to the dimensional standards of the industry to benefit both delivery and economy. Standard nominal thicknesses of granite offered by major fabricators are listed as follows:

10 mm (⅜ in.)	This is primarily a "thinset" floor tile thickness, and is limited to interior applications only.
20 mm (¾ in.)	The 20-mm (¾-in.) thickness is very common for interior cladding, interior flooring, or furniture applications. Exterior use of this thickness is not recommended.

30/32 mm (1¼ in.)	The 30-mm (1¼-in.) thickness is generally considered to be the minimum thickness suitable for exterior applications, although specific design criteria may dictate the use of thicker material.
40 mm (1⅝ in.)	The most typical usage of this thickness is exterior cladding panels when design loads marginally exceed the capacity of 30-mm (1¼-in.) material.
50 mm (2 in.)	Predominantly an exterior cladding material, 50-mm (2-in.) panels are used when necessitated by high design loads or large panel sizes. The machining of decorative reveals in the granite panel may also require that this thickness be used.
80 mm (3 in.)	Occasionally used in exterior cladding applications when extremely large panels are required or when deep recesses are cut into the stone. This thickness is also common in pavement applications that are subjected to vehicular traffic.
100 mm (4 in.), 150 mm (6 in.), and 200 mm (8 in.)	These thicknesses are generally found in landscape and site applications such as curbs, coping, steps, or fountains. Granite of these thicknesses or thicker is usually referred to as "cubic" material.

18. Availability

18.1 Granites are found throughout the world, and most are known by a unique trade name in the industry. In many cases, a particular granite will be given additional trade names by different fabricators or brokers. There are extreme examples of stone types that are known by a half dozen or more names in the industry, therefore, the trade name alone may not adequately identify the selected material. Including the origin (quarry location) and quarry operator of the material in the specification will help to minimize confusion.

18.2 For major projects, there is usually insufficient inventory of block material available at any one fabricator's facility to supply the project. Supply of raw block material from the quarry to the fabricator will occur concurrently with fabrication throughout the duration of the project construction. The production capacity of the quarry must be carefully considered to ensure uninterrupted delivery of material to the fabricator at the required rate. This is further complicated when the source of the granite is distant from the fabrication facility.

18.3 The size of blocks obtainable from a granite quarry is unique to the specific quarry. Natural fissures and fracture planes existing in the rock formation will dictate the available block size and block shape. Some granite materials have been supplied in monolithic forms approaching 15 m (ft) in length, while other granites will not be available in panels larger than 1 m^2. The supplier of the material must be consulted during design phases to ensure that the design requirements can be satisfied by the specified material.

18.4 Many granites are sold in varying "grades" or "selections." Oftentimes, terms such as "monumental," "structural," "architectural," "quarry-run," "select," "clear," or "variegated" are used with the tradename of the granite to further clarify the material specified.

COMMON DIMENSION STONE TYPES—MARBLE

19. Mineralogy, Appearance, and Texture

19.1 Geologically, marble is a metamorphic rock resulting from the recrystallization of limestone. Marble has both geological and commercial definitions. Geologically, the name marble is applied to rocks comprising crystallized grains of calcite (calcium carbonate) or dolomite (calcium magnesium carbonate), or both. Commercially, the name marble has come to be applied not only to rocks meeting the geological definition but also to rocks ranging from pure carbonate to those containing very little carbonate, yet having compositions and textures that permit them to be polished. The commercial marble group includes geologically true marbles; compact, dense limestones capable of being polished (limestone marbles); serpentine rocks (mostly or entirely hydrated magnesium silicate); and travertine (porous or cellularly layered, partly crystalline calcite).

19.2 Commercial marbles come in an almost unlimited palette of colors. They may be uniformly colored or a mixture of two or more colors. They may have bands or streaks in varying colors, called veining, contributing to any number of patterns. Geologic marbles of almost pure calcite or dolomite, or both, are white although trace minerals may contribute off-white background shadings and colorful veining. The color, veining, clouds, mottling, and shading in marbles are caused by substances included in minor amounts during formation. Iron oxides make the pink, yellows, browns, and reds. Most grays, blue-grays, and blacks are of carbonaceous origin. Greens are caused by micas, chlorites, and silicates.

20. Suitability for Use

20.1 Marble has been used architecturally for centuries. It is one of man's oldest building materials, as a dimension stone. Yet, not all marbles are suitable for use as exterior dimension stone.

20.2 Some of the basic considerations to be addressed in selecting a suitable marble for exterior use are as follows:

20.2.1 *Texture*—Texture is defined as that aspect of the physical appearance of a rock that is determined by size, shape, and mutual relations of the component grains or crystals. Texture plays a very important part in the physical strength and resistance to exterior exposures of marble. Marbles with a fine-grained, equigranular texture (grains of uniform size) tend to be less resistant to the effects of exterior exposure than those with a medium- to large-grained, inequigranular texture (grains of markedly varying sizes). The latter usually have an interlocking texture (grains with irregular boundaries, which interlock by mutual penetration).

20.2.2 *Physical Strength*—Physical strength properties of marble are determined by laboratory testing in accordance with ASTM standard test procedures for each physical property to be evaluated. Minimum or maximum values for each physical property, to aid in determination of a specific marble's suitability for exterior exposure, are in accordance with Specification C503.

20.2.3 *Soundness*—Marbles have been classified into four soundness groups. The basis of this classification is simply the usual fabrication and handling practices involved in working with the material. Practical experience with each material has deemed such practices to be both necessary and acceptable. The classification has no bearing on the cost of the material. The four groups are listed as follows:

20.2.3.1 *Group A*—Sound marbles with uniform and favorable working qualities; containing no geological flaws or voids.

20.2.3.2 *Group B*—Marbles similar to in character to Group A marbles, but with less favorable working qualities; may have natural faults; a limited amount of waxing,[3] sticking,[4] and filling may be required.

20.2.3.3 *Group C*—Marbles with some variations in working qualities; geological flaws, voids, veins, and lines of separation are common. It is standard practice to repair these variations by waxing,[3] sticking,[4] filling, or cementing. Liners and other types of reinforcement are used when necessary.

20.2.3.4 *Group D*—Marbles similar to Group C marbles, but containing a larger proportion of natural faults, maximum variations of working qualities, and requiring more of the same methods of finishing and reinforcing. This group comprises many of the highly colored marbles prized for their decorative values.

20.2.3.5 *Hysteresis*—Most dimension stones return to their original volume after exposure to high or low temperatures. Some marbles exhibit a phenomenon known as "hysteresis," or a permanent volume change after exposure to thermal cycling. Hysteresis typically manifests itself as a bowing of the marble panels, often suggesting a pillowed effect. In addition to the bowing, the face of the panels will become more porous, making the surface more vulnerable to attack by corrosive agents and freeze/thaw deterioration. If a marble which is subject to hysteresis is selected, careful research is required to determine the minimum thickness required to prevent failure of the cladding system.

20.3 Marble is a suitable and durable material for exterior dimension stone when properly selected, designed, and installed. The ultimate test for any specific marble is its past historical performance on existing structures. Some marbles, particularly those included in the Group C and D classifications, are not suitable for exterior use.

21. Standard Thicknesses

21.1 The following are standard thicknesses:

10 mm (3⁄8 in.)	Tiles in various size modules for "thinset" application of interior flooring and walls. Also used in exterior panelized systems with appropriate setting materials (for example, epoxy type or silicone type).
12 mm (1⁄2 in.)	Tiles in larger modules and some specialty commercial applications mostly for flooring where heavier traffic is anticipated. Also used in exterior panelized systems with appropriate setting materials (for example, epoxy type or silicone type).
20 mm (3⁄4 in.)	A standard slab thickness for use on interior walls, flooring and countertop work as well as specialty furniture type applications. May only be used on a *limited basis* for exterior walls, ground level work.
22 mm (7⁄8 in.)	Minimum thickness for toilet and shower partitions with stiles a minimum of 1¼ in. thick.
30/32 mm (1¼ in.)	A standard slab thickness for use on countertop work and interior walls. May be used for interior stair treads, sills, and specialty work. Also as a minimum thickness for use on exterior walls (multistory construction) and exterior pavers.
38/40 mm (1½-15⁄8 in.)	Used for exterior walls and pavers as well as specialty work (pilasters, trim, and molding interior or exterior).
50 mm (2 in.)	Used for exterior walls, pavers, and specialty work.
75 mm (3 in.), 100 mm (4 in.), 150 mm (6 in.), or greater	These thicknesses are referred to as "cubic," and are typically applied in monuments, sculptures, and decorative work.

[3] Waxing refers to the practice of filling minor surface imperfections such as voids or sand holes with melted shellac, cabinetmaker's wax, or certain polyester compounds. It does not refer to the application of paste wax to make the surface shinier. Not all materials commonly used for the purpose of waxing are durable in exterior exposures. Use of inappropriate materials may lead to unreasonable maintenance requirements or even failure of the marble.

[4] Sticking describes the butt edge repair of a broken piece of marble. This repair must include dowels or other mechanical anchors in conjunction with exterior grade adhesive.

22. Availability

22.1 Marbles suitable for exterior usage are readily available from quarries and production facilities in the United States and many other countries throughout the world. However, for very large projects requiring thousands of square feet of cladding surface, the ability of the quarry to produce such quantities in the required color selection or quality should be thoroughly investigated in advance.

COMMON DIMENSION STONE TYPES—LIMESTONE

23. Mineralogy, Appearance, and Texture

23.1 Limestone is a commercial rock term embracing both limestone and dolomite. It is a sedimentary rock composed principally of calcium carbonate (the mineral calcite) or the double carbonate of calcium and magnesium (the mineral dolomite), or a mixture of the two. Limestones, like all sedimentary rocks, contain impurities that affect their appearance and properties, and the amount, kind, and distribution of impurities affect the suitability of the rock for commercial use.

23.2 Limestones are found in hues of white, brown, gray, yellow, red, or black, but those used commercially are commonly in light earth tones of gray, buff, reddish or yellowish buff, or mixtures of these colors. The appearance of the stone is affected not only by color but also texture, which is the size, shape, and arrangement of component grains, skeletal minerals, and crystals; by stratification, which is composition, thickness, and arrangement of component beds; and by finish, which is brought about by milling or fabrication. Limestones range in texture from those so fine-grained as to lack visible particles through coarse in which individual fossil shells may be apparent. In general, surfaces of similar stone that are polished will be darker in appearance than those that are broken, cut, or sawed. The appearance of limestone may change over time with exposure to weather because of the oxidation of minerals and accumulation of organic matter.

24. Suitability for Use

24.1 Dimension limestones are subdivided into three categories by density in accordance with Specification C568:

24.1.1 *Low Density Limestone*—Limestone having a density ranging from 1760 to 2160 kg/m^3(110 to 135 lb/ft^3)

24.1.2 *Medium Density Limestone*—Limestone having a density greater than 2160 but not greater than 2560 kg/m^3(135 to 160 lb/ft^3)

24.1.3 *High Density Limestone*—Limestone having a density greater than 2560 kg/m^3(160 lb/ft^3)

24.2 Limestone has been successfully used as a dimension stone in all climates of the earth. Because there is a variety of physical properties found within the limestone group, it should be noted that a single variety of limestone may not be suitable for all applications. Selection of a limestone for use as a pavement application, for example, would involve different performance criteria than that for statuary or cladding applications.

24.3 Being of sedimentary origin, most limestone varieties are "anisotropic," or directionally specific in their physical and visual properties. As such, these materials generally have a preferred "rift," or plane of easiest splitting, direction. Some limestones do not display a preferential direction in splitting, and are generally referred to as "freestones."

25. Standard Thicknesses

25.1 Most limestone products are custom made to the designer's specifications. Ultimately, consideration of specific design requirements in conjunction with the stone's physical properties will provide a basis upon which to designate material thickness. Since standard slab depth may vary from one producer to another, it is best to check with the producer to determine the appropriate thickness to specify. The following list of standard thicknesses is provided only as a general guideline. Limestone is available in any number of incremental thicknesses beyond those listed.

20 mm (¾ in.) and 22 mm (⅞ in.)	Minimum thickness for interior flooring and wall veneer applications, limited to high-density limestone. Panel size and design criteria may dictate the use of thicker material.
38 mm (1½ in.)	Typical thickness of high-density limestone for interior flooring and wall veneer.
50 mm (2 in.)	Minimum recommended thickness for all applications of low- and medium-density limestone, although some producers may be able to provide a lesser thickness depending on the application. The minimum recommended thickness for exterior applications of high-density limestone is 50 mm (2 in.). Panel size and design criteria may dictate the use of thicker material.
76 mm (3 in.)	Typical thickness for exterior applications.
100 mm (4 in.)	Used when necessitated by high design loads or large panel sizes. The machining of decorative reveals in the limestone panel may also require that this thickness be used. The nominal thickness of standard splitface stone veneer is 100 mm (4 in.), often used in conjunction with brick.

26. Availability

26.1 Through time, the nature of the quarrying industry has changed from many small, relatively inefficient quarries, to a few large, relatively efficient quarries. Limestone used in older buildings may no longer be quarried today, but stone with similar color and texture may be found to match those no longer being produced.

COMMON DIMENSION STONE TYPES—QUARTZ-BASED

27. Mineralogy, Appearance, and Texture

27.1 The term "quartz-based" is the commercial definition used to define rock that has high contents of quartz and silica. Sandstone and bluestone are two common terms used to designate rocks of this type. Sedimentary in origin, this rock generally contains a wide variety of trace minerals that oxidize to produce a broad spectrum of colors, both within the deposit and characteristic to specific deposits.

27.2 Quartz-based stone can be found in shades from light buff to dark blue-gray. Composition also varies widely from coarse, well-defined grains of quartz to very fine, tightly bonded particles, which appear almost homogeneous in structure. The texture of the finish is affected by the basic structure of the rock. The finer the grain size, the smoother the finish that can be attained.

27.3 As all quartz-based stones are sedimentary in origin, they have specific bedding planes and are therefore "anisotropic," or directionally specific in their properties to varying degrees. This can affect the appearance or performance of the stone, or both.

28. Suitability for Use

28.1 Quartz-based stones are disbursed widely throughout the world. Ease of fabrication, as well as the range of available colors has made this type of stone popular for centuries.

29. Standard Thicknesses

29.1 The standard thicknesses are as follows:

20 mm (¾ in.) to 50 mm (2 in.)	Generally, this is the minimum range of thicknesses that are considered suitable for exterior paving applications for pedestrian traffic.
50 mm (2 in.) to 80 mm (3 in.)	These thicknesses are most often found in exterior cladding applications with low design loads or small panel sizes, or both.
125 mm (5 in.), and 150 mm (6 in.)	These thicknesses are most commonly used in coping, water tables, and belt courses.
200 mm (8 in.) to 450 mm (18 in.)	This range of thicknesses is used on architectural, monumental, and split-face ashlar applications.
200 mm (8 in.) to 600 mm (24 in.)	Used in landscape applications, such as retaining walls, steps, and curbs. Stone of these thicknesses are frequently load-bearing, and often referred to as "cubic stock."

30. Availability

30.1 Quartz-based stones are found in many areas of the United States. Stones of specific physical characteristics are found in localized geographical areas. Consideration must be given to the design requirements as well as the color. Capability of the supplier is a very important consideration. The supplier should be consulted during design to ensure that the design requirements do not exceed the fabrication capability of the specific stone.

COMMON DIMENSION STONE TYPES—SLATE

31. Mineralogy, Appearance, and Texture

31.1 Slate is a microcrystalline, metamorphic rock commonly derived from shale. The shales from which slates originate were deposited previously as clay beds. Slates are composed mostly of micas, chlorite, and quartz.

31.2 Slates are largely "anisotropic" or "directionally specific" in their properties. The micaeous minerals have a subparallel orientation resulting in very pronounced cleavage planes within the rock. This property enables most slates to be split into thin, strong sheets.

31.3 Slates vary in color from the monochromatic tones of black and gray to green, red, blue, purple, yellow, brown, buff, and mottled varieties. Gray and blue slates are so colored due to the presence of carbonaceous material, while most other colors are due to the presence of iron compounds.