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**Granite tiles and slabs for use in
Construction — Specification**

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Foreword

Rwanda Standards are prepared by Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS 261 was prepared by Technical Committee RSB/TC 09, Civil Engineering and Building Materials.

In the preparation of this standard, reference was made to the following standards:

- 1) SANS 1357:2008 *Granite surface plates and tables*
- 2) ASTM C615/C615M – 11 *Standard Specification for Granite Dimension Stone*

The assistance derived from the above source is hereby acknowledged with thanks.

This second edition cancels and replaces the first edition (RS 261: 2014), of which have been technically revised.

Committee membership

The following organizations were represented on the Technical Committee on Civil engineering and building materials (RSB/TC 9) in the preparation of this standard.

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TECOS Ltd

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Rwanda Housing Authority (RHA)

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Gasabo 3D

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Granite Tiles and Slabs for use in construction — Specification

1 Scope

This Draft Rwanda Standard specifies requirements for granite dimension stone such as granite tiles and slabs used in flooring, wall facing or cladding, work tops, skirting and any other use.

The granite specified in this standard is natural stone that is sawed, cut, split or otherwise finished or shaped.

This standard does not cover moulded, cast or otherwise artificially aggregated units composed of fragments, and also crushed and broken stone

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASTM C97 / C97M Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone

ASTM C170/C170M Standard Test Method for Compressive Strength of Dimension Stone

ASTM C99 / C99M Standard Test Method for Modulus of Rupture of Dimension Stone

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

ASTM C1353 / C1353M Standard Test Method for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic Using a Rotary Platform Abraser

ASTM C880 / C880M Standard Test Method for Flexural Strength of Dimension Stone

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

granite (commercial definition)

visibly granular, igneous and metamorphic rock generally ranging in colour from pink to light or dark grey and consisting mostly of quartz and feldspars, accompanied by one or more dark minerals. The texture is typically homogeneous, but may be gneissic or porphyritic. Some dark granular igneous and metamorphic rocks, though not granite proper, are included in the definition

3.2

granite (scientific definition)

visibly granular, crystalline rock with equigranular or inequigranular texture, normally having an essential composition of two feldspars (alkali/feldspar plus sodic plagioclase or two alkali feldspars), quartz, micas, hornblende and rarely pyroxene

3.3

texture

modified appearance of natural stone resulting from one or several mechanical treatments that is determined by size, shape and mutual relationships of component grains or crystals

Textures related to granites include:

- a) **Equigranular** - grains of approximately the same size.
- b) **Inequigranular** - grains of markedly unequal sizes.
- c) **Porphyritic** - A texture defined by relatively large grains (phenocrysts), typically feldspar that are distributed in distinctly fine grained matrix. The phenocrysts of porphyritic granites generally are rectangular or partly rounded in outline and may be as much as several centimetres in maximum dimension
- d) **Foliated** - a continuous or discontinuous layer structure in metamorphic rocks formed by the segregation or different minerals in streaks or lenticles, or by alternation of bands of different textures.

3.4

abrasive finish

flat non-reflective surface finish

2.5

honed finish

honed is a super fine smooth finish, though not as fine as a polished finish

3.6

cladding

non-load-bearing stone used as the facing material in wall construction that contains other materials

3.7

crack

partial break in the stone (seam)

3.8**polished finish**

the finest and smoothest finish available in stone characterized by a high luster (gloss) and strong reflection of incident light, generally only possible on hard, dense materials

3.9**sand/blasted finish**

matte-texture surface finish with no gloss, accomplished by exposing the surface to a steady flow of sand under pressure

3.10**durability**

measure of the ability of dimension stone to endure and to maintain its essential and distinctive characteristics of strength, resistance to decay, and appearance

3.11**pits**

small depressions, voids or pinholes in stone, especially on a finished surface

3.12**cut stone**

stone fabricated to specific dimensions

3.13**dimension stone**

natural stone that has been selected and fabricated to specific sizes or shapes

3.14**slab**

piece of stone having two parallel surfaces and produced by shaving or splitting in the first milling or quarrying operation

3.15**tile**

thin modular stone unit under 50mm thick

3.16

lot

not more than 10 tiles or slabs of the same size, type, and accuracy grade, from one manufacturer, submitted at any one time for inspection and testing

3.17

defective

surface plate that fails in one or more respects to comply with the relevant requirements of the specification

3.18

sound stone

stone which is free of cracks, fissures, or other physical defects

3.19

clamping ledge

margin of reduced thickness that is used for mounting clamps along an edge of a surface plate

3.20

flatness tolerance of work surface

distance separating two parallel planes between which the work surface can be contained

3.21

seam

flaw or crack in a granite plate

3.22

stiffness

resistance of a surface plate to sagging under load

4 Classification and type

4.1 Granite tiles and slabs occurs in various colours and shapes depending upon the source. Granite dimension stone specified in this standard shall be granite used for:

- a) exterior and interior cladding of buildings and structures;
- b) curbstone, paving, and landscape features;

- c) structural components having established dimensions;
- d) grade separations and retaining walls; and
- c) monuments.

4.2 Granite surface plates

Surface plates are usually used for mounting mechanical, electronic, and optical gaging systems

4.2.1 The type of surface plate shall be one of the following, as specified by the purchaser:

- a) Type 1: No clamping ledge.
- b) Type 2: Two clamping ledges, one on each of the longer sides of the rectangular plate, unless otherwise specified by the purchaser.
- c) Type 3: Four clamping ledges.

4.2.2 The proportions of clamping ledges on surface plates, when relevant, shall be as follows:

1) Plates less than 160 mm thick:

- Depth: not less than 40 % of plate thickness
- Overhang: approximately 25 % of plate thickness

2) Plates 160 mm thick and over:

- Depth: not less than 75 mm
- Overhang: not more than 50 mm

5 Physical Properties

5.1 General requirements

5.1.1 Granite supplied under this specification shall conform to the physical requirements specified in **Table 1**. for possible variations from this table.

5.1.2 Granite shall be sound, durable, and free of spalls, cracks, open seams, pits, or other defects that are likely to impair its structural integrity in its intended use.

5.1.3 Granite shall be free of minerals that may cause objectionable staining under normal environments of use.

5.1.4 The desired color and texture, with their permissible natural variations in material characteristics for all material to be produced for the project, shall be established by control samples. Select representative samples by viewing a sufficient number of physical samples prior to production that show the complete range of variations in color and texture of the granite specified.

Table 1 — Physical requirements

Physical Property	Test requirements A	Test method(s)
Absorption by weight, max %	0.4	ASTM C97/C97M
Density, min, kg/m ³	2560	ASTM C97/C97M
Compressive strength, min, c Mpa	131	ASTM C170/C170M
Modulus of rupture, min, Mpa	10.3	ASTM C99/C99M
Abrasion resistance, min, Ha D,E,F	25	ASTM C241/C241M / ASTM C1353
Flexural strength, min, Mpa	8.3	ASTM C880/C880M

^A The material property values in Table 1 were established using samples prepared according to the individual test methods, Finishes, other than those specified in the individual test methods, may result in a deviation from established values.

^B The material properties given in Table 1 represent properties of granite that have history of successful use for general building and structural purposes.

^C The minimum compressive strength, flexural strength, and modulus of rupture shall be based upon the minimum average strength of specimens tested in four conditions; wet or dry and parallel or perpendicular to rift.

^D pertains only to stone subject to foot traffic

^E The new abrasive is currently more aggressive, resulting in lower abrasive hardness values (Ha). Therefore, care should be taken when interpreting Ha values from tests using the new abrasive, particularly with regard to current ASTM stone standard specification requirements for abrasion resistance.

^F Abrasion Resistance test method ASTM C1353 will eventually replace Test Method C241/C241M and it is not necessary to perform both tests. Availability of the proper equipment and materials by the testing laboratory may determine which test is performed.

5.1.5 Stiffness of surface plates

When tested in accordance with 6.4, a surface plate of size 400 mm × 250 mm or larger shall have a thickness or a modulus of elasticity (or both) such that it is capable of supporting a mass load of 250 kg/m² of work surface area centrally without deflecting by more than one-half of the appropriate flatness tolerance (see 5.2.5.1.b), measured along a diagonal at the centre of the plate.

5.2 Sizes

5.2.1 Granite block

Granite blocks shall be supplied in the form of cubes with the following dimensions:

- a) The length shall be 2.5m to 4m;
- b) The width shall be 1m to 2m;and
- c) The height shall be 1m to 2m.

NOTE Dimensions more than the above mentioned may be produced as per the customer's demand and the cutting machine in use.

5.2.2 Granite slabs

5.2.2.1 Granite slabs shall be rectangular or square and of specified dimensions. The tolerance in length and breadth shall be ± 2 mm and thickness ± 1 mm. The bottom face may be rough but the top surface shall be fine dressed and joint faces shall be dressed back square with the top surface for at least 50 mm, without hollowness or spalling off.

5.2.2.2 The granite slabs shall be supplied in the sizes given below:

- a) The length shall be 2 000 to 4 000mm
- b) The width shall be 600mm to 1 500mm
- c) The thickness shall be 20 mm to 100 mm

NOTE The width of 600 mm to 850 mm can be produced using "cutting disc" with diamond segment. width more than 850 mm can be produced using gang saw cutting machines.

5.2.3 Granite tiles

The granite tiles shall be supplied in sizes given below:

- a) 600 mm \times 300 mm;
- b) 600 mm \times 600 mm
- c) 500 mm \times 250 mm;
- d) 400 mm \times 400 mm;
- e) 300 mm \times 300 mm;
- f) 200 mm \times 200 mm; and
- g) 100 mm \times 100 mm.

The thickness of tiles shall be 10 mm, 15 mm and 20 mm in the same piece.

5.2.4 Custom sizes

Sizes and shapes other than those specified may be supplied as agreed between the supplier and the purchaser depending on the design requirements. However, thickness should not be below 10 mm for tiles and 20 mm for slabs.

5.2.5 Granite surface plates sizes

The size of a surface plate shall be one of those given in column 1 of table 2 , as specified by the purchaser.

Table 2 — Size of surface plates

Size of plate*, i.e. nominal length* x nominal width* mm	Nominal surface area mm	Approx. diagonal of plate mm	Thickness of plate min., mm	Nominal mass of plate kg
160 x 100	1,6	188	50	2,4
250 x 160	4,0	296	50	5,9
400 x 250	10,0	471	50	14,8
400 x 400	16,0	566	70	33
630 x 400	25,0	745	70	52
630 x 630	40,0	891	70	82
100 x 630	63,0	1 180	100	186
1 000 x 1 000	100,0	1 414	100	295
1 600 x 1 000	160,0	1 880	160	755
2 000 x 1 000	200,0	2 236	200	1 180
2 500 x 1 600	400,0	2 960	250	2 950
3 500 x 1 600	560,0	3 848	300	4 956

* Plates sizes, except 2 000 mm x 1 000 mm and 3 500 mm x 1 600 mm x 1 600 mm, correspond to the number series R5.
 + The actual dimensions shall be subject to a tolerance of +2% , - 0%
 ± Based on a density of 2 950 kgm³

5.2.5.1 Side faces

5.2.5.1.1 **Chamfers:** All edges and corners shall be chamfered as follows:

Table 3 — chamfers for different plate sizes

Size of plate	chamfer
160 mm x 100 mm	a2 mm
250 mm x 160 mm	
400 mm x 250 mm	a3 mm
630 mm x 400 mm	
> 630 mm x 630 mm	a5 mm
The corresponding slope lengths shall be approximately 3, 4, and 7 mm respectively.	

5.2.5.1.2 The **squareness** tolerance of the side faces of a type 1 surface plate relative to the work surface shall be subject to agreement between the purchaser and the manufacturer.

5.2.6.1 The **flatness** tolerance of the side faces of a type 1 surface plate shall be subject to agreement between the purchaser and the manufacturer.

5.3 Tolerance

5.6.1 The following tolerance shall be allowed on tiles, slabs and skirtings whether they are standard sizes or custom sizes:

5.6.1.1 Slabs Tolerance

- | | |
|--------------|------------|
| a) Length | ± 2 mm |
| b) Width | ± 2 mm |
| c) Thickness | ± 1 mm |

5.6.1.2 Tiles Tolerance

- | | |
|---------------------|------------|
| a) Linear Dimension | ± 1 mm |
| b) Thickness | ± 1 mm |

5.6.1.3 Surface plates tolerance

Flatness: When a surface plate is tested in accordance with clause 7, the accuracy grade shall conform to one of the grades 00, 0, 1, or 2, as specified by the purchaser. The rounded-off values of the flatness tolerances corresponding to these accuracy grades and the various nominal lengths of surface plates are given in table 4.

The values give in Table 4 have been calculated from the following formulae:

For any accuracy of 00, flatness tolerance = $(2 + \frac{L}{500})\mu m$

For any accuracy of 0, flatness tolerance = $(4 + \frac{L}{250})\mu m$

For any accuracy of 1, flatness tolerance = $(10 + \frac{L}{100})\mu m$

For any accuracy of 2, flatness tolerance = $(20 + \frac{L}{50})\mu m$

where L is the nominal length of the surface plate in millimetres.

Table 4 - Flatness tolerances of surface plates

Length of surface plate mm	Flatness tolerance for accuracy grades μm			
	00	0	1	2
160	2	5	12	23
250	3	5	13	25
400	3	6	14	28
630	3	7	16	33
1 000	4	8	20	40
1 600	5	10	26	32
2 000	6	12	30	60
2 500	7	14	35	70
3 500	9	18	45	90

6 Finish

6.1 The granite tiles and slabs shall be sound, durable and free of imperfections such as stains, cracks, pits, or other defects that would impair its strength, durability or appearance.

6.2 The faces of granite slabs and tiles shall be supplied with one of the following finishes:

- a) Sand-blasted and/or abrasive finish;
- b) Honed finish;
- c) Polished finish.
- d) Flamed finish

Note: granite slabs and tiles will have a one side of the surface polished; other surface finishes like Sand-blasting, honing and flaming can be done on demand.

6.3 The edges of the slabs and tiles shall be true and straight, but may be profiled, bull nosed or chamfered and can be polished or left unpolished depending on the customer's requirements.

6.4 Machine cut tiles and slabs with square edges may be supplied if so specified by the customer/purchaser.

6.5 When so required by the purchaser, a surface plate shall be provided with a properly fitting cover or other means of protecting the work surface and the edges when the plate is not in use. The cover may be of plywood, well seasoned timber, or a derivative of wood suitably treated with a varnish or other coating to give the desired finish.

7 Sampling and testing

7.1 Samples, if required, for testing to determine the characteristics and physical properties shall be representative of the granite to be used.

7.2 In any consignment, all the slabs, surface plates or tiles of the same group, size and finish shall be grouped together to constitute a lot. Samples shall be selected and tested separately for each lot for determining its conformity or otherwise to the requirements of the specification.

7.3 The number of slabs, surface plates or tiles to be selected for the sample shall depend upon the size of the lot and shall be in accordance with table 3. The slabs or tiles in the sample shall be selected at random and in order to ensure the randomness of selection, random number tables may be used.

Table 4 sample size and criteria for conformity

Number of slabs, tiles in the lot (L)	Number of slabs, or tiles to be selected in sample		Permissible number of defectives
$L \leq 25$	3		0
$26 \leq L \leq 100$	5		0
$101 \leq L \leq 200$	8		0
$201 \leq L \leq 500$	13		0
$501 \leq L \leq 1000$	20		1
Lot size surface plates	Sample for inspection surface plates	Sample for testing surface plates	
1 -- 4	All	1	0
5 -- 10	5	1	0

7.4 All the slabs, surface plates or tiles selected in the sample shall be examined for dimensions, finish and general requirements. Any slab, surface plate or tile failing in any one or more of the above requirements shall be considered as defective. A lot shall be considered as conforming to these requirements if the number of defective obtained is not more than the permissible number of defectives given in column 3 of table 4.

8 Inspection

The purchaser/customer or his authorized representative shall, if he so desires, be granted facilities for inspection of finished slabs or tiles prior to dispatch from the supplier's works.

9 Marking

Each type of granite slabs and tiles should be permanently labelled clearly and indelibly with the following information:

- name of manufacturer or trade mark; and
- the number and size of the tile.

c) accuracy grade

d) serial number

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Annex A (normative)

Water absorption test method

A.1 sampling

The sample shall be selected to represent a true average of the type or grade of stone under consideration and shall be of the quality supplied to the market under the type designation to be tested. The sample may be selected by the purchaser or his authorized representative from the quarried stone or taken from the natural ledge and shall be of adequate size to permit the preparation of at least five test specimens. When perceptible variations occur, the purchaser may select as many samples as are necessary for determining the range in properties.

A.2 Test specimens

The specimens may be cubes, prisms, cylinders, or any regular form with least dimension not under 50 mm and greatest dimension not over 75 mm but the ratio of volume to surface area shall not be less than 8 nor greater than 12.5. All surfaces shall be reasonably smooth. Saw or core drill surfaces are considered satisfactory, but rougher surfaces shall be finished with No. 80 abrasive. No chisels or similar tools shall be used at any stage of preparing the specimens. At least five specimens from each sample shall be prepared.

A.3 Procedure

A.3.1 Dry the specimens for 48 h in a ventilated oven at a temperature of $60^{\circ}\text{C} \pm 2^{\circ}\text{C}$. At the 46th, 47th, and 48th hour, weigh the specimens to ensure that the weight is the same. If the weight continues to drop, continue to dry the specimens until there are three successive hourly readings with the same weight.

A.3.2 After drying, cool the specimens in the room for 30 min and weigh. When the specimens cannot be weighed immediately after cooling, store them in a desiccator. Determine the weights to the nearest 0.01 g.

A.3.3 Immerse the specimens completely in filtered or distilled water at $22^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 48 h. At the end of this period remove them from the water bath one at a time, surface dry with a damp cloth, and weigh to the nearest 0.001g.

A.4 Calculation and Report

Calculate the weight percentage absorption for each specimen as follows:

$$\text{Absorption, weight \%} = \frac{B-A}{A} \times 100$$

where;

A = weight of the dried specimen, [g], and

B = weight of the specimen after immersion, [g].

Calculate the mean water absorption of the sample as the average of the weight percentage absorption for all specimens.

A.5 Report

The report shall contain the following information:

- a) Identity of party providing the sample;
- b) Name of stone;
- c) Identity of sample;
- d) Mean water absorption of sample;
- e) Any variations to the procedure, including specimen dimensions, given in this standard;
- f) Weight of dried specimen;
- g) Weight of soaked and surface-dried specimen in air; and
- h) Percentage water absorption by weight of specimen.

Annex B (normative)

Compressive strength test - Test method

B.1 Apparatus

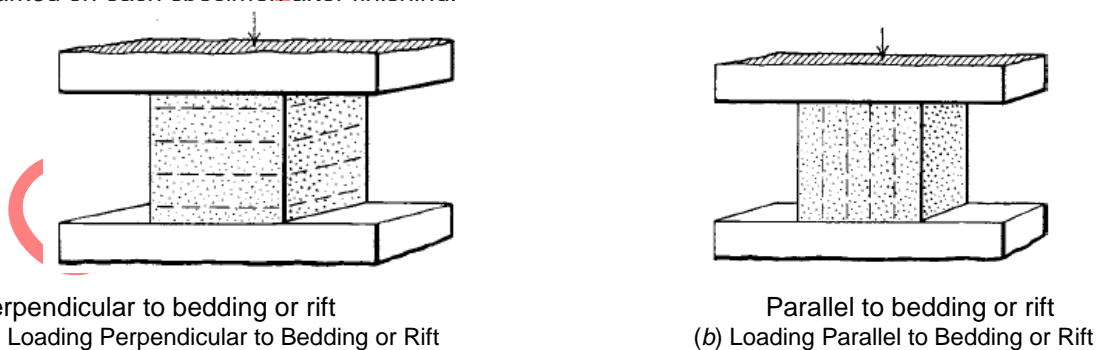
In vertical testing machines, the spherical bearing block shall be suspended from the upper head of the machine in such a manner that the contact plate remains in a central position (spherical surfaces in full contact) when not loaded. The spherical surfaces shall be well lubricated, and the center of curvature shall lie in the surface of contact with the specimen.

B.2 Sampling

The sample shall be selected to represent a true average of the type or grade of stone under consideration and shall be of the quality supplied to the market in finished form under the type designation to be tested. The sample may be selected by the purchaser or his authorized representative from quarried stone or taken from the natural ledge and shall be of adequate size to permit the preparation of the desired number of test specimens. When perceptible variations occur, the purchaser may select as many samples as are necessary for determining the variation in compressive strength.

B.3 Test specimens

The test specimens may be cubes or cylinders and shall be cut from the sample with saws or core drills. The diameter or lateral dimension (distance between opposite vertical faces) shall be not less than 50 mm, and the ratio of height to diameter or lateral dimension shall be 1:1. At least five specimens shall be prepared for each condition of the test; that is, when the compressive strength is desired for the wet and dry conditions but in only one direction, such as perpendicular to the bed (or rift) (see Figure B1(a)), ten specimens will be required. For wet and dry strength tests both perpendicular and parallel to the bed (or rift) (see Figure B1(a) and (b)), twenty specimens are required. The load-bearing faces shall be finished by grinding to as nearly true and parallel planes as practicable. The load-bearing surfaces and the direction of bedding (or rift) shall be marked on each specimen after finishing.



NOTE Dashed lines indicate direction of bedding or rift. Arrows indicate direction of loading.

Figure B 1 - Methods of applying load with reference to bedding or rift

The load-bearing areas of the specimen shall be calculated from measurements taken midway between the load bearing surfaces. The dimensions of the specimens shall be measured to the nearest 0.5 mm) and the load-bearing areas calculated to the nearest 0.10 mm².

B.4 Conditioning

Before testing the specimens in a dry condition, dry them for 48 h at 60°C ± 2°C. At the 46th, 47th, and 48th h, weigh the specimens to ensure that the weight is the same. If the weight continues to drop, continue to dry the specimens until there are 3 successive hourly readings with the same weight. After removing the specimens from the oven, cool them to room temperature in a desiccator before testing them.

Before testing the specimens in a wet condition, immerse them in water for 48 h at 22°C ± 2°C. Test them immediately upon removal from the bath, wiping the specimens free of surface water.

B.5 Procedure

Position the specimens at the centre of the testing machine and apply the initial load at a rate that will permit hand adjustment of the contact plate on the specimen. Rotate the plate back and forth through an angle of about 30° under a small load to properly seat the spherical block, but take care not to move the specimen out of the central position. Preferably, the rate of loading should not exceed 0.5 MPa/s, but this requirement may be considered as being met if the speed of the loading head is not more than 1 mm/min.

B.6 Calculation

Calculate the compressive strength of each specimen as follows:

$$C = \frac{W}{A}$$

where;

C = compressive strength of the specimen, MPa

W = total load, N, on the specimen at failure, and

A = calculated area of the bearing surface in mm².

Round each individual result to the nearest 1 MPa.

B.7 Report

Report the average of all values of compressive strength of specimens loaded perpendicular to the bedding (or rift) as shown in Figure B1(a) in a dry condition as the compressive strength perpendicular to the rift in a dry condition. Similarly, report the values perpendicular/wet, parallel/dry as shown in Figure B1(b) and parallel/wet. All determinations shall be reported as information.

The following additional information shall be reported:

- a) identification of the sample, including name and location of the quarry, name or position of the ledge, date when sample was taken and trade name or grade of stone;
- b) size and shape of specimens used in the tests; and a description of the way in which the specimens were prepared.

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Annex C (normative)

Modulus of rupture - test method

C.1 Apparatus

C.1.1 Testing machine

The accuracy of the testing machine shall be within 1 % for the range from 50 to 5000 N.

C.1.2 Load Application and Support Blocks

The supports for the specimen shall be of the rocker type (Figure C1) with edges at least as long as the width of the specimen. The load application block may be of either the rocker or rigid type. The portions of the load application and support blocks contacting the stone shall be rounded, with a nominal radius of 13 mm.

C.2 Sampling

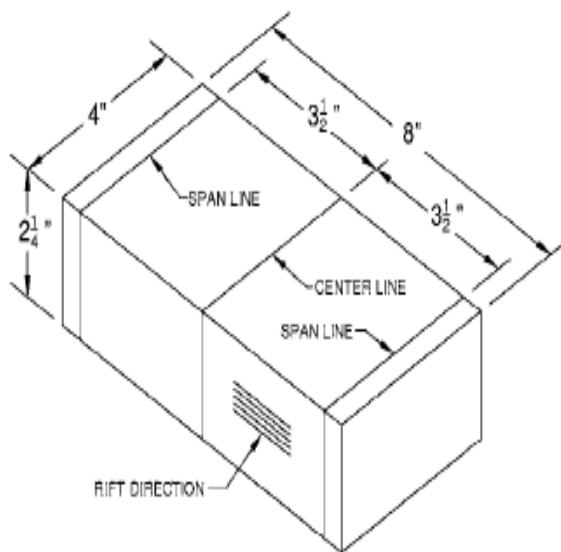
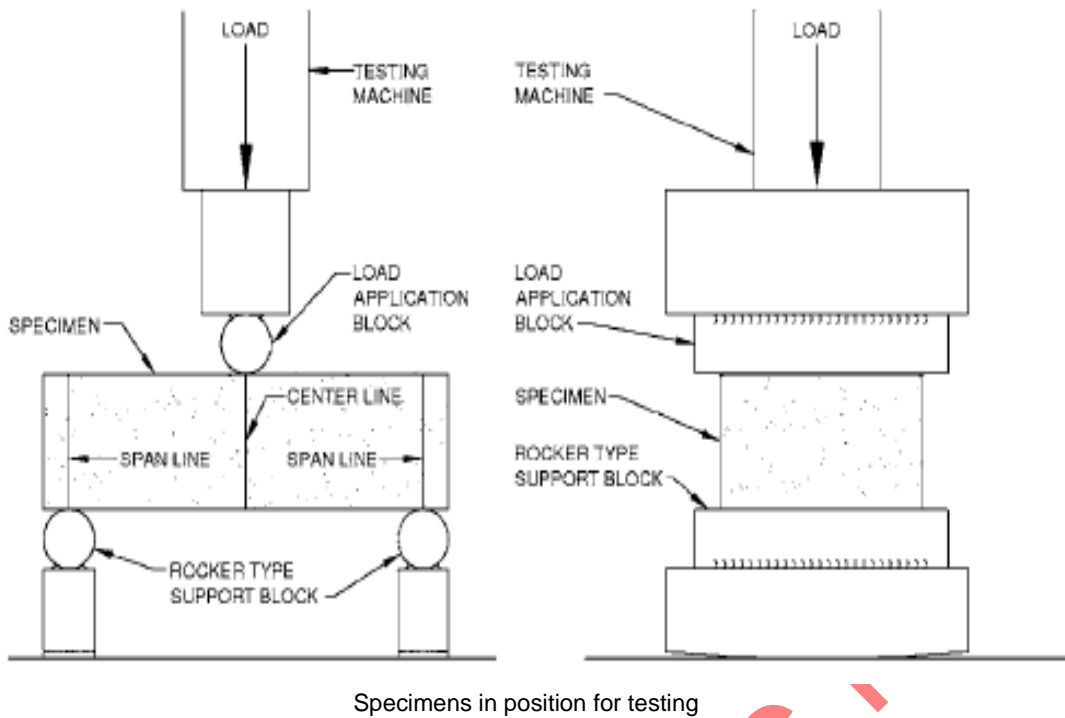
Select the sample to represent a true average of the type or grade of stone under consideration and of the quality supplied to the market under the type designation to be tested. The sample may be selected by the purchaser or his authorized representative from the quarried stone or taken from the natural ledge and shall be of adequate size to permit the preparation of the desired number of test specimens. When perceptible variations occur, the purchaser may select as many samples as are necessary for determining the variations in modulus of rupture.

C.3 Test specimens

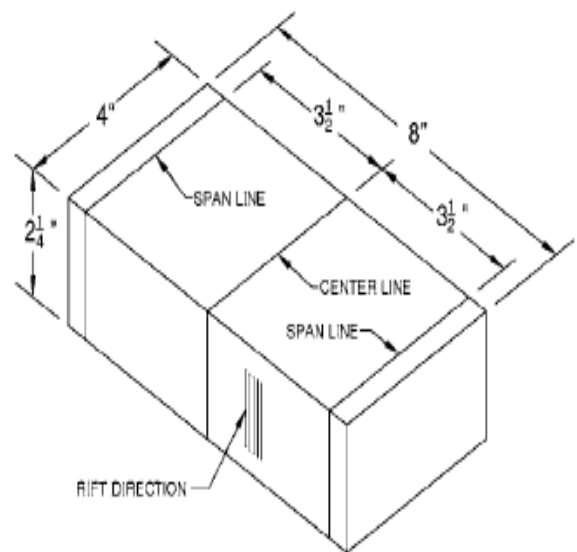
The specimens shall be 100 by 200 by 60 mm in size and fabricated to tolerances of 62 mm. They shall be sawed from the sample and finished by grinding to smooth surfaces. The 100 by 200-mm faces shall be as nearly plane and parallel as practicable. For loading perpendicular to the rift (Note 1) five specimens shall be prepared with the 100 by 200-mm faces parallel to the rift planes (see Figure C1), and for loading parallel to the rift, five specimens shall be prepared with the 100 by 60-mm faces parallel to the rift (Note 2). When tests are desired on the stone in both the wet and dry condition, ten specimens shall be prepared for each direction of loading; that is, five for tests dry, perpendicular to the rift, five for tests wet, perpendicular to the rift, etc.

NOTE 1 The term rift is used here to designate the direction in which the stone splits most easily. In stratified stones it is considered to coincide with the bedding or stratification. The rift direction should always be marked on the sample by the quarryman, since it often is not possible to determine it on a small block.

NOTE 2 Another condition of loading may occur in structures when the rift planes are vertical and parallel to the length of the beam. The strength of the stone may be obtained for such loading by cutting the specimens with the 260 by 200-mm face parallel to the rift. The meager data available for this condition of loading indicates that the strength is at least as high as when the load is applied perpendicular to the rift as shown in Figure C 1.



Specimen for testing perpendicular to lift



Specimen for testing parallel to lift

Note: 1 inch is equivalent to 25.4 mm

Figure C.1 Specimens and preferred type of load application and support blocks for determining the modulus of rupture of building stone

C.4 Marking and measuring specimens

On the 100 by 200-mm face, draw the center line perpendicular to one edge 60 by 200-mm face and extend down both edges perpendicular to the 4 by 100 by 200-mm face. At a distance of 90 mm each way from the center line, draw two similar sets of lines (span lines in Figure C1). Mark each specimen to indicate the direction of the rift and label with suitable numbers or letters for identification in measuring and testing.

Measure the dimensions of the cross section on the center line. Measure the width to the nearest 0.1 mm and take the thickness as the average of three measurements to the nearest 0.1 mm, one taken at the center and one near each edge.

C.5 Conditioning

C.5.1 Before testing the specimens in a dry condition, dry them for 48 h at 60°C±2°C. At the 46th, 47th and 48th hour, weigh the specimens to ensure that the weight is the same. If the weight continues to drop, continue to dry the specimens until there are three successive hourly readings with the same weight. After removing the specimens from the oven, cool them to room temperature in a desiccator before testing them.

C.5.2 Before testing the specimens in a wet condition, immerse them in water for 48 h at 22°C ±2°C. Test them immediately upon removal from the bath, wiping the specimens free of surface water.

C.6 Procedure

Lay the specimen flatwise on the support blocks, spaced 180 mm apart and equidistant from the load application block (Note 3), with all three load application and support blocks parallel. When a load of 50 N has been applied, stop the loading and make all load application and support blocks coincide with the marks on the specimen by centering the specimen under the load application block and moving the support blocks under the span marks. Apply the loading at a rate not exceeding 5000 N/min until failure of the specimen.

NOTE 3 When all three load application and support blocks are of the rocker type, care shall be taken to adjust all three until the top face of the specimen is horizontal when loaded.

C.7 Calculation

Calculate the modulus of rupture of each specimen as follows:

$$R = \frac{3W}{2bd^2}$$

where;

R = modulus of rupture, MPa,

W = breaking load, N,

l = length of span, mm,

b = width of specimen, mm, and

d = thickness of specimen, mm.

C.8 Report

Report the average of all values of modulus of rupture for test specimens loaded perpendicular to the rift as the modulus of rupture perpendicular to the rift, and report the average for all test specimens loaded parallel to the rift as the modulus of rupture parallel to the rift. In case any specimen gives a value of as much as 20 % under the average it shall be examined for defects and, if the low value appears to be due to a flaw or faulty

test piece, report the average of the remaining specimens of the group as the modulus of rupture of the sample for the condition of loading under consideration. Report all determinations as information.

Report the following additional information:

- a) Identification of the sample, including the name and location of the quarry, name and position of the ledge, date when sample was taken, and trade name or grade of the stone;
- b) Size and shape of specimens used in the test; and
- c) A description of the way in which the specimens were prepared

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Annex D (normative)

Abrasion resistance - Test method

D.1 Apparatus

The abrasion testing apparatus shown in Fig. D1 shall be used. This apparatus consists essentially of a power-driven grinding lap, A, 250 mm in diameter, which is revolved at 45 rpm; three specimen holders, B, with superimposed weights; gears, C, for revolving the specimen; and a means of feeding abrasive at a constant rate to the lap. The guide rings, D, are clamped in position slightly above the specimen holders, and the 2000 g weight bearing on the specimen is the combined weight of the specimen holder, vertical shaft above with the attached spur gear, and a weight hopper, E, containing additional adjustment weights. The frame, F, carrying the guide rings is adjustable vertically to accommodate different specimen thicknesses. Gears, C, are adjusted on the shafts for each specimen thickness, so that they are slightly above the plate, G, throughout the test.

D.2 Sampling

The sample may be selected by the purchaser or his authorized agent but shall represent the average quality of the type or grade of stone under consideration. It shall be of sufficient size to permit the preparation of at least three test specimens, and one face should have the finish to be exposed to traffic. The sample preferably should be 25 mm thick and 200 mm square.

D.3 Test specimens

At least three specimens 50 mm square and preferably 25 mm in thickness shall be sawed from the sample. The sharp edges shall be rounded by grinding to a radius of approximately 1 mm in order to prevent crumbling during the test.

D.4 Conditioning

Dry the specimens for 48 h in a ventilated oven at a temperature of $60^{\circ}\text{C} \pm 2^{\circ}\text{C}$. At the 46th, 47th, and 48th hour, weigh the specimens to ensure that the weight is the same. If the weight continues to drop, continue to dry the specimens until there are three successive hourly readings with the same weight. After removing the specimens from the oven, cool them to room temperature in a desiccator before testing them.

D.5 Procedure

D.5.1 Weigh the test specimens to the nearest 0.01 g; then place them in the abrasion testing apparatus. Remove the specimens from the apparatus, brush them free of dust, and weigh to the same precision as for the original weights.

D.5.2 Place the specimens in water for an hour or more, surface dry them with a towel, and weigh again. Weigh the specimens in water and calculate the bulk specific gravity.

NOTE 1 Humidity affects the results to some extent in that the rate of grinding is higher for higher humidity. For this reason it is advisable to make the test when the relative humidity is between 30 and 40 %.

NOTE 2 The abrasive hardness value, H_a , is the reciprocal of the volume of material abraded multiplied by ten. The superimposed weight on the specimen is 2000 g and this is augmented by the weight of the specimen itself. The correction for the weight of the specimen, included in the formula, is based on the fact that the rate of abrasion is directly proportional to the weight. By basing the abrasive resistance values on the volumes, rather than the weights abraded, a better comparison is obtained for materials that vary considerably in bulk density.

D.6 Calculation

Calculate the abrasion resistance of each specimen as follows (Note 2):

$$H_a = 10.95G (2000 + W_s) / 2000W_a$$

where;

G = bulk specific gravity of the sample,

W_s = average weight of the specimen (original weight plus final weight divided by 2), in g, and

W_a = loss of weight during the grinding operation, in g.

D.7 Report

The average of the tests on individual specimens, expressed to two significant figures, shall be reported as the abrasive resistance of the sample, but all results shall be reported as information. The report shall identify the type and grade of stone, its source, and the approximate date of removal from the quarry.

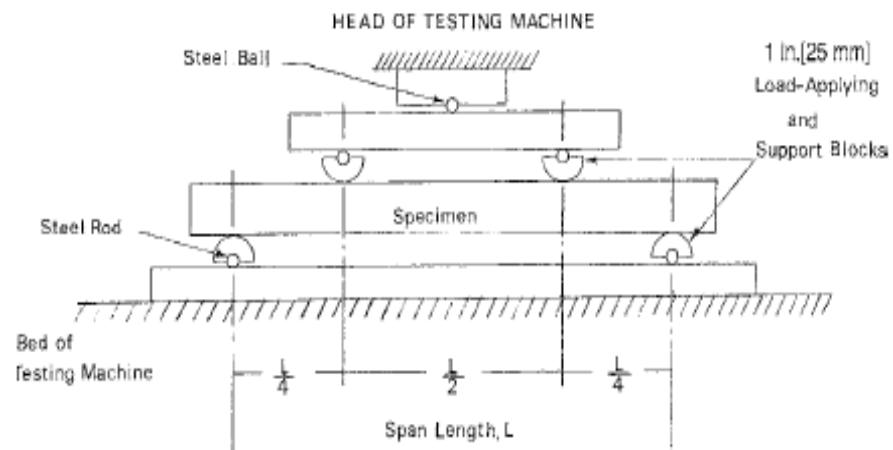
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Annex E (normative)

Flexural strength - test method

E.1 Apparatus

Testing machine (Fig. E.1), conforming to the requirements of the applicable sections of Practices E.4. The quarterpoint loading method shall be used in making flexure tests of stone employing bearing blocks which will ensure that forces applied to the beam will be vertical only and applied without eccentricity. The apparatus should be capable of maintaining the span length and distances between load-applying blocks and support blocks constant within 61 mm. The load should be capable of being applied at a uniform rate and in such a manner as to avoid shock.



NOTE 1—Apparatus may be used inverted.

Figure E.1 Diagrammatic view of a suitable apparatus for flexure test of stone

E.2 Sampling

Select the sample to represent a true average of the type or grade of stone under consideration and of the quality supplied to the market under the type designation to be tested.

The sample may be selected by the purchaser or his authorized representative from the quarried stone or taken from the natural ledge and shall be of adequate size to permit the preparation of the desired number of test specimens. When perceptible variations occur, the purchaser may select as many samples as are necessary for determining the variations in flexural strength.

E.3 Test specimen

E.3.1 The test specimens shall measure 100 mm wide by 30 mm thick by 350 mm long, with a span as tested of 300 mm. The sides of the specimen shall be at right angles with the top and bottom. The specimens shall have a fine abrasive finish on the planes perpendicular to the load and a fine saw finish on the other four planes. The dimensions of the specimen shall be measured and recorded to the nearest 0.1 mm. A minimum

of five specimens shall be tested for each condition of test. The average value of the test results is reported as the flexural strength of the stone.

E.3.2 Where the material thickness has been set (for example, the thickness of the stone panels for the project has been established), it is often requested to perform flexure tests at the job thickness. The following shall govern the specimen size where it is requested to test at the material thickness and it is other than 30 mm. The span as tested shall be 10 times the thickness. The specimen lengths shall be not less than 50 mm and not more than 100 mm greater than the span as tested. Where the thickness is less than 70 mm, the width of the specimen shall be 100 mm. Where the thickness is greater than 70 mm the width shall be 1.5 times the thickness. Where the thickness is other than 30 mm and the specimen size is in accordance with the job thickness criteria noted in the foregoing, the average value of the test results shall be reported as the flexural strength of the stone at the material thickness.

E.3.4 Where the material surface finish has been set (for example, the architectural finish on the panels for the project has been established), it is often requested to perform flexure tests on specimens with the finish the same as on the material. The following shall govern when it is requested to test at the material surface finish. The specimens shall have a finish on one plane perpendicular to the load in accordance with the finish specified for the material. Unless there is data to the contrary, the positioning of the specimen should be with the finished face in flexural tension. The average value of the test results shall be reported as the flexural strength of the stone at the job surface finish.

E.3.5 Test results obtained by this test method are those of flexural strength properties. In specific applications, test specimens of different geometry may give useful results in terms of a modulus of rupture value.

E.4 Conditioning

E.4.1 Before testing the specimens in a dry condition, dry them for 48 h at 60°C±2°C. At the 46th, 47th and 48th hour, weigh the specimens to ensure that the weight is the same. If the weight continues to drop, continue to dry the specimens until there are three successive hourly readings with the same weight. After removing the specimens from the oven, cool them to room temperature in a desiccator before testing them.

E.4.2 Before testing the specimens in a wet condition, immerse them in water for 48 h at 22°C ± 2°C. Test them immediately upon removal from the bath, wiping the specimens free of surface water.

E.5 Procedure

E.5.1 Assemble the apparatus and place the specimen on the span supports and adjust the quarter point loading blocks into contact with the specimen.

E.5.2 Apply the load at a uniform stress rate of 4 MPa/min to failure.

E.6 Calculation

Calculate the flexural strength, σ as follows:

$$\sigma = \frac{3WL}{4bd^2}$$

where;

σ = flexural strength, MPa,

W = maximum load, N,

L = span, mm,

$L = 10 d$,

b = width of specimen, mm, $b \geq 1.5d$, and

d = depth of specimen, mm.

E.7 Report

The report shall include the following:

- a) stone type;
- b) sizes of the specimens used;
- c) preconditioning procedure used;
- d) individual test results for each specimen;
- e) average value of the test results for each group using the following relation:

$$\text{Average } \sigma = \frac{\text{sum of observed values}}{\text{number of tests}}$$

- f) standard deviation, s , of the test results for each group using the following relation:

$$s = \sqrt{\frac{\text{sum of } (\text{observed value} - \text{average } \sigma)^2}{\text{number of tests} - 1}}$$

- g) any variations from the above procedural techniques.

The following additional information shall also be reported:

- i. identification of the sample,
- ii. name and location of the quarry

iii. name and position of the ledge, date when sample was taken, and

iv. trade name or grade of the slate.

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- [3] ASTM C 99 *Standard Test Method for Modulus of Rupture of Dimension Stone*
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