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Slabs of natural stone for external paving — Requirements and test methods

ICS 73.020; 91.100.15

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In order to match with technological development and to keep continuous progress in industries, standards are subject to periodic review. Users shall ascertain that they are in possession of the latest edition

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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 520 was prepared by Technical Committee RSB/TC 9, *Civil engineering and Building materials.*

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

1) EN 1341:2012: Slabs of natural stone for external paving - Requirements and test methods

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

Committee membership

The following organizations were represented on the Technical Committee on *Title of TC* (RSB/TC 9) in the preparation of this standard.

A+ Construction Group Ltd

Africeramics Ltd

Consultants Engineers Group (CEG) Ltd

D&D Resources Ltd

Dutureheza Ltd

Enabel Rwanda

Greenpack Africa Ltd

Integrated Polytechnic Regional Centre (IPRC) — Musanze

Mass Design Group

NP Construction Company (NPCC) Ltd

Road Transport Development Agency (RTDA)

Rwanda Housing Authority

Rwanda Inspectorate, Competition and Consumer Protection Authority (RICA)

Rwanda Quarries Association (RQA)

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SKAT Consult

St Joseph Engineering Company (SJEC) Ltd

Standards for Sustainability (SfS)

Stonecraft Industries Ltd

University of Rwanda — College of Science and Technology (UR — CST)

Slabs of stones for external pavement — Requirement and test method

1 Scope

This Standard specifies the performance requirements and the corresponding test methods for all natural stone slabs used for external paving and road finishes.

Note: External paving use includes all pavements typical of road works, such as pedestrian and trafficked areas, outdoor squares and similar to be used in an outdoor condition that are subject to the weathering agents, such as temperature changes, rain, wind, etc.

This Standard provides also for the evaluation of conformity and for marking of the natural stone slabs.

This Standard covers also characteristics that are of importance to the trade.

This standard does not cover natural stone slabs for floors and stairs in buildings.

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.

DRS 515, Natural stone – Terminology

DRS 517, Masonry units manufactured from natural stones - Specification

DRS 525, Natural stone test methods — Determination of water absorption coefficient by capillarity

DRS 526, Natural stone test methods — Determination of real density and apparent density, and of total and open porosity

DRS 527, Natural stone test methods — Petrographic examination

DRS 528, Natural stone — Denomination criteria

DRS 530, Natural stone test methods — Determination of geometric characteristics on units

DRS 532, Natural stone test methods — Determination of the abrasion resistance

DRS 533, Natural stone test methods — Determination of flexural strength under concentrated load

DRS 534, Natural stone test methods — Determination of the slip resistance by means of the pendulum tester

3 Terms and definitions

For the purposes of this standard, the following terms and definitions given in DRS 515 and the following apply.

4.1

term

text of the definition

3.1

external paving slab

unit of natural stone obtained by cutting or splitting used as a paving material, used for external paving and road finishes in which the working width exceeds two times the thickness

3.2

upper face

surface of a slab intended to be seen when in use

3.3

bed face

surface of a slab intended to be in contact with the bedding material when in use

3.4

side face

surface of a slab perpendicular to upper face and intended to be vertical in use

3.5

work dimension

dimension of a slab, specified for its manufacture, to which the actual dimension is to conform within specified permissible tolerances

3.6

actual dimension

dimension of a slab as measured

3.7

irregular plan form

slab of random plan dimensions

3.8

thickness

distance between the upper face and the bed face of the slab

3.9

overall length

longer side of the rectangle with the smallest length able to enclose the slab

3.10

overall width

shorter side of the rectangle with the smallest area able to enclose the slab

3.11

textured

slab face with a surface finish produced by secondary processing, from a saw or hewn surface

3.12

fine textured

surface finish with a maximum difference of 1,0 mm between peaks and depressions (e.g. polished, honed or sawn with a diamond disc or blade)

3.13

coarse textured

surface finish with more than 1,0 mm difference between peaks and depressions (e.g. dolly pointed, shot blasted or flame textured)

3.14

hewn

slab face or edge with a rough surface finish, e.g. a riven or split face or edge

3.15

tooled

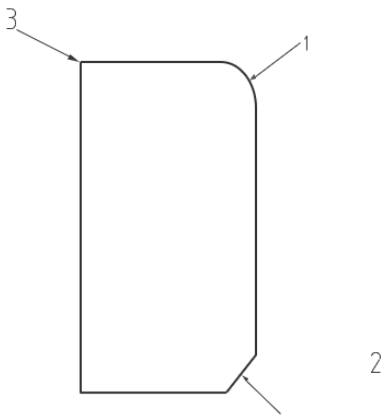
coarse finish resulting from mechanical surface treatment and showing tool marks

3.16

arris

edge produced by the meeting of two surfaces

Note 1: Sharp, rounded and chamfered arrises are shown in Figure 1.



Where,

1 rounded arris
2 chamfered arris
3 sharp arris

Figure 1 — Illustration of types of arris

3.17

lower expected value

E_L

value which corresponds to the 5 %-quantile of a logarithmic normal distribution for a confidence level of 75 %

3.18

higher expected value

E_H

value corresponds to the 95 %-quantile of a logarithmic normal distribution for a confidence level of 75 %

4 Requirements and test methods for slabs of natural stone

4.1 General

4.1.1 Denomination

The denomination shall always be declared in accordance with DRS 528 (meaning traditional name, petrological family, typical colour and place of origin as precisely as possible for example geo coordinates).

4.1.2 Alteration of physical properties of the natural stone

If during production the natural stone slabs have been subjected to a treatment that physically alters the properties of the stone (e.g., chemical treatment, patching, or filling or other similar products for natural holes, faults or cracks), then the use of such treatment shall be stated.

In addition, specimens for testing shall be representative of the product and any processes that the stone is subjected to.

4.2 Dimensions

4.2.1 General

The work dimensions of the slabs shall be declared unless they are being supplied in random lengths. Where supplied in random lengths, only the widths and thickness shall be declared.

Dimensions shall be measured in accordance with DRS 530.

4.2.2 Permissible tolerances

4.2.2.1 Plan dimensions (excluding slabs with irregular plan form)

Plan dimensions of a slab shall be measured in accordance with DRS 530, and the deviations from the declared dimensions shall conform to the tolerances given in Table 1.

Table 1 — Tolerances on plan dimension

	Tolerances on plan dimension of slabs [a] for:		
	Class 0	**Class 1**	**Class 2**
Marking designation	P0	P1	P2
Sawn edges	No requirement	±4 mm	±2 mm
Hewn and tooled edges		±10 mm	±10 mm
[a] For natural stone slabs with regular plan form only.			

The two diagonals of a rectangular slab shall be measured in accordance with DRS 530, and the maximum difference between them shall not exceed the values given in Table 2.

Table 2 — Tolerances on diagonals

	Tolerances on diagonals of slabs [a] for:		
	Class 0	**Class 1**	**Class 2**
Marking designation	D0	D1	D2
Sawn edges	No requirement	6 mm	3 mm
Hewn and tooled edges		15 mm	10 mm

[a] For natural stone slabs with regular plan form only.

Note: Tolerances stricter than P2 and D2 shall be declared

4.2.2.2 Thickness

The thickness of a slab shall be measured in accordance with DRS 530, 5.2, and the deviations from the declared thickness shall conform to tolerances given in Table 3.

Table 3 — Tolerances on thickness

	Tolerances on thickness of slabs for:		
	Class 0	**Class 1**	**Class 2**
Marking designation	T0	T1	T2
30 mm thick	No requirement [a]	±3 mm	±10 %
30 mm < thickness 80 mm		±4 mm	±3 mm
80 mm thick		±7 mm	±4 mm

[a] Manufacturers are encouraged to declare deviations measured in accordance with DRS 530, 5.2.

Note: Dimensions between faces may be declared as a range of nominal minimum-maximum thicknesses, e.g. 30 –60 mm and a tolerance declared on the limits of the range. This is particularly applicable to hewn slabs. Tolerances stricter than T2 may be declared.

4.2.2.3 Face irregularities

The face irregularities on hewn slabs, measured in accordance with DRS 530, 5.3, shall never be greater than 20 mm above the work thickness and not below the work thickness (i.e. (+20/-0) mm) and the greatest measured value shall be declared.

4.2.2.4 Flatness and straightness

4.2.2.4.1 Arrises

The straightness along the arrises of textured slabs plan dimensions shall be measured in accordance with DRS 530, 5.4, and the deviations from the declared straightness shall conform to tolerances given in Table 4.

Table 4 — Tolerances on straightness along arrises

	Tolerances on straightness along arrises of slabs		
	Class 1	**Class 2**	**Class 3**
Longest test straight edge	0,5 m	1 m	1,5 m
Fine textured face	±2 mm	±3 mm	±4 mm
Coarse textured face	±3 mm	±4 mm	±6 mm

4.2.2.4.2 Faces

Flatness and bow shall be measured in accordance with DRS 530, 5.4, and the deviations from the declared flatness and bow shall conform to tolerances given in Table 5 unless the surface is riven in which case information on the deviations shall be declared.

The vertical faces of hewn or tooled slab shall be undercut relative to the top arrise by no more 12 mm for a slab 80 mm thick or less and by no more 15 mm for slab greater than 80 mm thick. The vertical faces shall not be overcut by more than the permitted dimensional tolerance.

Table 5 — Tolerance on flatness for faces

Tolerance on flatness for faces for		
a) Fine textured face		
Gauge length mm	**Max. convex tolerance mm**	**Max. concave tolerance mm**
300	2,0	1,0
500	3,0	2,0
800	4,0	3,0
1 000	5,0	4,0
b) Coarse textured face		
Gauge length mm	Max. convex tolerance mm	Max. concave tolerance mm
300	3,0	2,0
500	4,0	3,0

800	5,0	4,0
1 000	8,0	6,0

4.2.2.5 Arrises

Arrises described as square or sharp shall have a bevel with horizontal or vertical dimensions not exceeding 2 mm at the manufacturer's discretion.

When slabs are supplied with a chamfered or rounded arris, the dimensions shall be declared and the vertical and horizontal dimension shall be within ±2 mm of the declared dimensions.

4.2.2.6 Angles and special shapes

Each slab angle shall be in accordance with the agreed geometry. Pieces of special or irregular shape shall be checked for compliance with the required shape by use of a specified template, the permissible tolerance at any point shall be in accordance with Table 1.

Note1: Deviations stricter than in Table 1 may be declared.

Note 2: Deviations may not be added to each other, e.g. deviations on thickness and flatness.

4.3 Breaking strength flexural strength

The flexural strength shall be determined using the test method in DRS 533 and the lower expected value(EL) shall be declared

An identification test as defined in DRS 533 is normally carried out. However, where the surface finish of the delivered product is known, the test may be carried out with this finish, in accordance with the technological tests defined in DRS 533.

NOTE 1 Guidance on the appropriate thickness for different classes of use is given in Annex A.

NOTE 2 An example of the calculation used to determine the lower expected value is given in Annex C.

4.4 Abrasion resistance

The abrasion resistance shall be determined using the test method in DRS 532 and the higher expected value (EH) shall be declared.

4.5 Slip and skid resistance

4.5.1 Slip resistance

The slip resistance shall be declared when the intended use of the slabs is subject to regulatory requirements, or upon request, and, in any case, when the roughness of the surface, measured following DRS 530, 5.3, is less than 1,0 mm.

The slip resistance shall be determined and the results expressed in accordance with the test procedure for wet conditions in DRS 534.

NOTE 1 Coarse textured and hewn slabs are assumed to give satisfactory slip resistance.

NOTE 2 The unpolished slip resistance value (USRV) relates to slabs as manufactured and helps to ensure adequate slip/skid resistance on installation.

NOTE 3 Experience has indicated that a USRV measurement, made using a wide slider/full swing on a pendulum that is greater than 35 in wet conditions, can usually be considered acceptable for surfaces that are horizontal or sloping at less than 6 %.

4.5.2 Skid resistance

Where required, skid resistance shall be declared.

In the absence of a national or ISO test method, skid resistance shall be determined and declared according to national provisions valid in the place of use of the product.

4.5.3 Durability of slip and skid resistance

When required, durability of slip and skid resistance shall be declared.

In the absence of Rwanda standard test methods, durability of slip and skid resistance shall be determined and declared according to national provisions valid in the place of use of the product.

4.6 Appearance

4.6.1 General

The colour, veining, texture, etc. of the natural stone shall be identified visually, typically by a reference sample of the same stone suitable for providing a general description of visual appearance.

A reference sample shall be provided by the supplier of the stone according to 5.6.2.

4.6.2 Reference sample, visual inspection and acceptance criteria

A reference sample shall be an adequate number of pieces of natural stone of sufficient size to indicate the general appearance of the finished work. The dimensions of individual pieces shall be at least 0,01 m2 (typical values are between 0,01 m^2 and 0,25 m^2 in face area but may be greater) and shall indicate the range of appearance regarding the colouring, the vein pattern, the physical structure and the surface finish. In particular the reference sample shall show specific characteristics of the stone, such as typical holes, glass seams, spots, crystalline veins and rusty spots.

The reference sample does not imply strict uniformity between the sample itself and the actual supply; natural variations may always occur.

If the processing of the stone involves the use of patching, fillers or other similar products for natural holes, faults or cracks, then the reference sample shall similarly display the impact of the same on the finished surface.

All the characteristics as shown by the reference sample shall be considered typical of the stone and not as flaws, therefore they shall not become a reason for rejection, unless their concentration becomes excessive and the typical character of the stone is lost.

The name and address of the manufacturer or the supplier of the stone, as well as the denomination of the stone in accordance with 5.1 and/or information on the treatment in accordance with 5.1.1, above, shall be indicated on the reference sample.

Any comparison between production sample and reference sample shall be carried out by placing the reference sample against the production samples and viewing them at a distance of about 2 m under normal daylight conditions and recording any visible differences in the characteristics of the stones.

4.7 Water absorption

Where required the water absorption shall be determined using the test method in DRS 525 and the higher expected value (EH) shall be declared.

4.8 Apparent density and open porosity

The apparent density and open porosity shall be determined using the test method in DRS 526 and the mean values declared.

4.9 Petrographic description

A petrographic description shall be provided, including a petrographic name, of the stone type, in accordance with DRS 527.

5 Evaluation of conformity

5.1 General

The conformity of the product (i.e. natural stone slabs) to the requirements of this standard and with the declared performances (e.g. values, classes) for the characteristics relevant for the intended use of the product, shall be demonstrated by:

a) initial type testing,

b) factory production control by the manufacturer, including product assessment.

For the purposes of testing, the products may be grouped into product families, where it is considered that the results for one or more characteristics from any product within the family are representative for the same characteristics for all products within that family.

A product may be in more than one family for different characteristics.

5.2 Initial type testing (ITT) - Type Testing (TT)

Initial type testing and type tests, if any, shall be performed for all characteristics included in this standard for which the performances are to be declared:

— when a new product type is developed (and before it is placed on the market or

— at the beginning of a new or modified method of production where this may affect the declared performances.

The declared performances should be representative of the current production, e.g. the lower expected value in normal production.

Whenever a significant change occurs in the raw material or the production process, which could change any of the declared performance of the product, this shall be considered as a new product and any of such characteristic shall be re-assessed for a new declared performance

Reference to the test method standards should be made to allow the selection of a suitable representative sample.

All essential characteristics, given in bold in Table 6, for which the manufacturer declares performances, are subject to Initial Type Testing.

In addition, the need to perform Type Tests applies to all other characteristics included in Table 6, when the manufacturer claims compliance, unless the standard gives provisions for declaring performances without performing tests.

Initial type testing and type tests of the product shall be carried out on:

c) first application of this document or at the beginning of the production with a new type of stone;

d) when significant variations occur in the material, determined visually or by significant changes in FPC results.

Tests previously performed in accordance with the provisions of this document (i.e., same type of stone, same characteristic measured with the same test method, same sampling procedure and system of attestation of conformity) may be taken into account for the purpose of ITT.

Table 6 Characteristics of natural stone slabs for paving for initial type testing and type tests

Requirements subclause	Characteristics (properties)	Test method in accordance with:	Expression of results
4.3	Breaking strength - Flexural strength	DRS 533	Declared value
4.5.1	Slipperiness – Slip resistance	DRS 530	Declared value
4.5.2	Skid resistance	See 5.5.2	Declared value
4.5.3	Durability of slip and skid resistance	See 5.5.3	Declared value
4.2.2.6	Tolerances – Angles and special shapes	See 5.2.2.6	Table 1
4.4.	Abrasion resistance	DRS 532	Declared value
4.7	Water absorption	DRS 525	Declared value
4.8	Apparent density and open porosity	DRS 526	Declared values
4.9	Petrographic description	DRS 527	Declared description

Assessment of compliance should be undertaken using the same method (identification or technological).

The declared performances may be supported by a test report supplied with the block or raw slabs provided that test have been performed according to the requirements and test methods of this Rwandan Standard.

5.3 Factory production control

5.3.1 A factory production control system (FPC) shall be established and documented. The factory production control system shall consist of procedures for the internal control of production. The results of the tests carried out

during FPC shall demonstrate that products placed on the market conform to this document and with the declared performances of the product's characteristics, established under ITT in accordance with Clause 4.

In cases when the processing of the natural stone is likely to change any of these declared performances, relative to the initial stone (e.g. as a consequence of the type of processing or because the physical properties have been modified by impregnation, use of patching, fillers or other similar products for natural holes, faults, cracks and similar), then this shall be considered within FPC as requested by this document.

5.3.2 The factory production control shall consist of regular inspection checks and tests and the utilisation of the results to control incoming materials (i.e. stone), equipment, the production process and the product.

When alternative tests to the reference tests are used for the test procedure, their correlation to the reference test shall be determined and available for inspection.

All test equipment shall be calibrated and the procedure, frequency and acceptance criteria stated.

5.3.3 A sampling plan for the testing of products shall be defined and the results shall be recorded and available for inspection.

NOTE Guidance on sampling is given in Annex B.

5.3.4 The stock control of the products, together with procedures for dealing with non-conforming products, shall be detailed.

5.3.5. Manufacturers' records shall include at least the following:

a) identification of the product tested;

b) information on sampling:

c) place and date of sampling;

d) identification of the production lot sampled;

e) frequencies of sampling;

f) size and number of samples;

g) test methods applied;

h) test and inspection results;

i) calibration records of apparatus.

5.3.6 Any testing procedure (reference or alternative tests) adopted for the FPC shall include the relevant acceptance criteria. In case of noncompliance, a specific action plan shall be defined as part of the FPC. As a rule, this plan shall include the repetition of the FPC procedure on an extended quantity of specimens or of products. In cases when the results of these tests do not conform with the declared performances, final assessment of compliance shall be provided adopting the same test method (identification or technological) as used in determination of declared performances and making reference to Table 7.

Table 7 Characteristics of natural stone slabs for paving for factory production control

Requirement		Verification during production	Verification on finished product		
Subclause	Characteristics (properties)		Test method in accordance with:	Minimum testing frequency (see 1) and 3) below)	Acceptance criteria
4.2.1	Dimensions		DRS 530		
4.2.2.1	Tolerances – Plan dimensions		DRS 530		

4.2.2.2	Tolerances – Thickness		DRS 517	Each lot	Within the tolerance range [a]
4.2.2.3	Tolerances – Face irregularities		DRS 517		
4.2.2.4.1	Tolerances – Flatness and straightness – Arrises		DRS 517		
4.2.2.4.2	Tolerances – Flatness and straightness – Faces		DRS 517		
4.2.2.5	Tolerances – Arrises		See 4.2.2.5		
4.2.2.6	Tolerances – Angles and special shapes		See 4.2.2.6 [c]		
4.4	Flexural strength		DRS 517	Every 2 years [b]	>80 % of the individual results >declared value
4.8	Water absorption		DRS 525		>80 % of the individual results <declared value
4.9	Apparent density and open porosity		DRS 526		No requirement
4.5	Abrasion resistance		DRS 532		>80 % of the individual results <declared value

Table 7 (continued)

Requirement		Verification during production	Verification on finished product		
Subclause	Characteristics (properties)		Test method in accordance with:	Minimum testing frequency (see 1) and 3) below)	Acceptance criteria
4.6.1	Slip resistance	Continuous verification in accordance with	DRS 534		≥ declared value
4.6.2	Skid resistance		See 4.6.2		≥ declared value
4.6.3	Durability of slip resistance Durability of skid resistance		See 4.6.3		≥ declared value

4.10	Petrographic description	manufacturer's factory production control (See 2) below)	DRS 527	Every 10 years [b]	Complies with declared description
4.11	Dangerous substances		See 4.11		Individual results complying with declared value or class

1) The testing frequency should be established so that it represents a means to guarantee constancy of the product's performance and a reliable declaration for both the users and the manufacturer.

2) The control testing of each of these characteristics is to be carried out using the most appropriate indirect test/check method(s), which is to be detailed in the manufacturer's quality control plan for the parameter(s), set up under ITT, if any, and related to the performance of such characteristic (e.g., incoming materials, composition).

3) In cases when the processing of the stone is likely to change the characteristics of the finished product relative to the initial material (e.g., as a consequence of the type of processing or because the use of patching, fillers or other similar products for natural holes, faults, cracks and similar), then this has to be considered in determining the frequency of testing.

[a] Usually referred to in the requirements subclause.

[b] These represent the upper limits of the testing frequency (see 1)).

[c] Only where special shapes are being produced.

6 Marking, labelling and packaging

As a minimum of identification, each consignment of natural stone slabs shall carry the following indications:

a) the denomination of the natural stone in accordance with DRS 528 (see 4.1.1);

b) the quantity and dimensions of the slabs.

Additional information is advisable:

c) the mass of the slabs;

d) dimensions and mass of packaging.

These indications shall be given on labels, packaging or on accompanying documents.

An identification system may be used in order to identify individual slabs; in such a case individual stones shall be clearly marked accordingly. Marking usually consists of alphanumeric codes and symbols (e.g. to define proper orientation at installation).

The slabs shall be clean before packaging.

Packaging shall allow adequate, solid and durable protection for packed slabs, both during transport and during handling and storage. Movement of slabs inside the packaging shall be prevented by securing individual pieces.

Packaging shall be of appropriate mass and size in consideration of transportation and lifting facilities; the top and bottom of the packaging as well as stacking possibility shall be indicated.

Safety against contamination, caused by packaging materials, in wet or dry conditions, shall be ensured. Packaging and tapes which are likely to stain shall not be used. Sensitive polished surfaces of the slabs shall be protected by appropriate means (e.g. plastic foil). Products with caustic properties shall not be used.

Annex A
(informative)

Guidance on the appropriate thickness for different classes of use

A.1 General

A number of structural calculation methods are available for determining the thickness of paving slabs for specific situations and loadings and these should be used for designing paving and roads in natural stone slabs.

However, if a simple method is required as part of the selection process, then the method described in A.2 can be followed.

A.2 Simplified method for the calculation of slab thickness

The thickness of a slab may be determined by calculation from the minimum required breaking load *P* (in kN) using the formula

$$t\sqrt{\frac{1500.P.L.F_S}{W.R_f}}$$

Where:

t is the thickness of the slab (in mm),

P is the breaking load (in kN), for the expected use of the paving,

NOTE Guidance on expected breaking loads for different uses is given in Table A.2.

L is the length of the slab (in mm),

W is the width of the slab (in mm),

Rf *is the lower expected value (EL) for flexural strength (in MPa) determined in accordance with WD 3 XXX: 2022 ,*

F_S is a safety factor, as given in Table A.1.

Table A.1 Safety factor (F_s)

Dimension *L* mm	Safety factors, F_s, for slabs on				
	Paving over		Paving over a gap, supported		
	concrete using mortar and joints (bound construction)	sand or aggregate (unbound construction)	on 4 sides	on 2 sides	on 4 corners
≤ 600	1,2	1,8	2,4	2,7	3,0
> 600	1,8	2,4	2,7	3,1	3,5

A.3 Guidance on expected breaking loads

Guidance on expected breaking loads for different uses is given in Table A.2.

Table A.2 — Breaking load

Class	Minimum breaking load kN	Typical use
0	No requirement	Decoration
1	0,75	Slabs bedded in mortar, pedestrian area only
2	3,5	Pedestrian and cycles areas
3	6,0	Occasional car, light vehicle and motorcycle access. Garage entrances
4	9,0	Walking areas, market places occasionally used by delivery vehicles and emergency vehicles
5	14,0	Pedestrian areas often used by heavy lorries
6	25,0	Roads and streets, petrol stations

Annex B
(informative)

Guidance on sampling

B.1 General

The annex specifies guidelines for methods for obtaining samples of natural stone from quarries, plants and construction works. Sampling from buildings may be necessary if the delivered natural stone slab is already applied in construction works.

The aim of sampling is to obtain a bulk sample that is representative of the average properties of the batch and of its variability.

The methods described are based on manual procedures. The methods described are limited to building and civil engineering purposes.

It is important that samplers are accordingly trained in the application of the methods set out in this Rwandan Standard.

In case of dispute or if tests are to be done by more than one organisation, all interested parties should have the opportunity to observe the sampling and should agree upon the number of sampling increments to be taken.

B.2 Principles of sampling

Proper and careful sampling and sample transport is a prerequisite for an analysis that can give reliable results. An adequate number of samples should take to obtain a good estimation of the natural heterogeneity of the batch.

The sampler should be informed of the aim of the sampling.

B.3 Taking bulk samples

The number and sizes of samples depend on the test methods for which they are taken. The number and shapes of specimens required are given in the relevant test methods.

B.4 Preparing a sampling plan

A sampling plan should be prepared, prior to sampling, taking into account the following:

a) type of natural stone;

b) aim of the sampling, including a list of the properties to be tested;

c) identification of sampling points;

d) orientation of samples relative to resource or bed, etc

e) approximate size of samples;

f) number of samples;

g) sampling apparatus to be used;

h) methods of sampling;

i) marking, packaging and dispatch of the samples.

B.4.1 Sampling apparatus

Any suitable cutting equipment for natural stone may be used for sampling. In addition, drills, which are suitable for taking drill cores, may be used.

B.4.2 Sampling methods

B.4.2.1 General

The sampling methods will inevitably involve the samplers working at a quarry, plant or construction works. Regulations for safety and ergonomics should be followed.

B.4.3 Sampling from quarries

B.4.3.1 General

The main objective of sampling from such deposits is to establish, where possible, the average, the range of variations and the differences in the structure and properties of the rock, taking account of the fabric and geological structure and the anticipated mining conditions.

B.4.3.2 Sampling of solid rock

a) Identification of anisotropy and orientation of samples

If the exploratory work reveals a pronounced fabric or geological structure, which is not necessarily visible at the sample scale (e.g. stratification, massive bedding, lamination, cleavage or rift), the sample should be marked accordingly.

b) Sampling for petrographic analysis

For petrographic analysis hand specimens should be taken from all distinct types and varieties, which characterise the rock in terms of mineral composition, fabric and geological structure.

Samples from drilling (cores and pieces) may also be used.

In addition to samples of fresh material, samples should also be taken to illustrate the effects of weathering. c) Sampling for physical testing

For physical testing, sample blocks and hand specimens should be used as samples, their number and location depending on the results of the petrographic analysis and the test methods required.

The sample blocks should measure approximately 0,40 m × 0,25 m × 0,25 m, or more where a coarse-grained and/or a large-pored rock is to be sampled.

The sample blocks should be broken as carefully as possible. It is recommended that they are taken from larger natural stones, which have been least affected by blasting. Care has to be taken to ensure that neither the sample blocks nor the hand specimens show any hairline cracks resulting from the removal process.

Samples may also be cut from rough blocks, slabs or dimension stones, the number and size of samples depending on the particular test method.

B.4.4 Sampling from production units and consignments

A representative sample of adequate size and characteristic of the rock in terms of mineral composition, fabric and geological structure, should be taken from the material to be tested (e.g. slabs, dimension stones), taking into account the intended use of the material.

B.4.5 Sampling from construction works

Sampling points should be selected according to the rules for obtaining a representative sample taking into consideration any differences in properties visible to the naked eye. Where necessary, taking a single slab to assess the mechanical properties of slabs, should be sufficient.

The location of the sample in the construction works should be reported.

B.5 B.7 Marking, packaging and dispatch of the samples

The samples or containers should be clearly and durably marked. Marking should include:

a) unique code; or

b) identification of the laboratory samples, place of sampling, date of sampling and denomination of the material.

The laboratory samples should be packed and transported in such a way that they are protected from damage.

B.5 Sampling report

B.8.1 The sampler should prepare a sampling report for each laboratory sample or for each group of laboratory samples from a single source. The sampling report should refer to this document and state:

a) sampling report identification (serial number);

b) laboratory sample identification mark(s);

c) date and place of sampling;

d) sampling point or identification of the batch sampled;

e) reference to the sampling plan prepared according to B.4;

f) name of the sampler(s).

B.8.2 Depending on the circumstances, other information might be relevant. Table B.1 shows an example of a comprehensive sampling report.

Table B.1 Example of a sampling report

Sampling report identification (serial n°):	
Laboratory sample identification mark:	no. of package

Description of the natural stone and sampling places

Name of the quarry or production plant or building:
Name of producer:
Origin of batch:
Purpose for which the natural stone is to be used:
Location of sampling point(s):
Identification of the batch:
Size of the batch:
Other comments (e. g. warnings, if appropriate):

Description of the sampling method

Date and time of sampling:
Reference to sampling plan used:
Sampling procedure (drilling, cutting, etc.):
Purpose of the sampling:

Samples

No. and dimensions of samples:

Other comments:
Dispatch of the samples:
Sampler(s) (print name):

Contract details

Contract identification:
Name and address of party requesting the sampling:…….. ……
Name of person(s) present at sampling:…… ……
Signatures:…… …… ……

Annex C
(informative)

Example of calculation of Lower Expected Value

C.1 Scope

This annex establishes a method for the statistical treatment of test results obtained following the natural stone test method described in this standard.

C.2 Symbols and definitions

Measured values	$x_1, x_2, \ldots x_i \ldots, x_n$
Number of measured values	n
Mean value	$\bar{x}_1 = \frac{1}{n}\sum_i x$
Standard deviation	$\bar{s}_1 = \mp\sqrt{\frac{\sum(x_i-\bar{x})^2}{n-1}}$
Coefficient of variation	$V = \frac{s}{x}$, (for individual values)
Logarithmic mean	$\bar{x}_{\ln} = \frac{1}{n}\sum_i lnx_i$
Logarithmic standard deviation	$\bar{s}_{\ln} = \mp\sqrt{\frac{\sum(lnx_i-\bar{x}_{ln})^2}{n-1}}$
Maximum value Max	Max
Minimum value Min	Min
Lower expected value	$E = e^{(\bar{x}_{ln}-(k_s*s_{\ln}))}$, where ks (quantile factor) is given in Table A.1
Quantile factor	k_s see Table A.1

C.1 Calculation of Lower Expected Value

For the calculation of the lower expected value (E_L) a logarithmic normal distribution is assumed. The lower expected value (E_L) corresponds to the 5 % quantile of a logarithmic normal distribution for a confidence level of 75 %.

Table C.1 Quantile factor (k_S) in dependence on the number of measured values (n) in correspondence to the 5 % quantile for a confidence level of 75 %

n	k_s
3	3,15
4	2,68
5	2,46
6	2,34
7	2,25
8	2,19
9	2,14
10	2,10
15	1,99
20	1,93
30	1,87
40	1,83
50	1,81
∞	1,64

Quantile factor (*k*s) dependent on the number of measured values (*n*) in correspondence to the 5 % quantile for a confidence level of 75 %.

The following examples should help to clarify the method:

EXAMPLE 1

Calculation of mean value, standard deviation, maximum value and minimum value of six measured values

Table C.2 Calculation of mean and standard deviation

Measurement no	Measured value *x*
1	2 000
2	2 150
3	2 200
4	2 300
5	2 350
6	2 400

Mean value	2 333
Standard deviation	147
Maximum value	2 400
Minimum value	2 000

EXAMPLE 2

Calculation of mean value, standard deviation, coefficient of variation and lower expected value of 10 measured values

Table C.3 Calculation of lower expected value

Measurement no	Measured value *x*	(ln *x*)
1	2 000	(7,60)
2	2 150	(7,67)
3	2 200	(7,70)
4	2 300	(7,74)
5	2 350	(7,76)
6	2 400	(7,78)
7	2 600	(7,86)
8	2 750	(7,92)
9	2 900	(7,97)
10	3 150	(8,06)
	---------	---------
Mean value	2 480	(7,807)
Standard deviation	363	(0,143)
Variation coefficient	0,15	

From Table C.1 for: *n* = 10 *k*s = 2,1 and the Lower expected value 1 81

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