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Foreword

Rwanda Standardsarepreparedby 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.

DRS537 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 772-1:2011Methods of test for masonry units - Part 1: Determination of compressive strength

2) EN 772-10, Methods of test for masonry units — Part 10: Determination of moisture content of calcium silicate and autoclaved aerated concrete units

3) EN 772-2, Methods of test for masonry units — Part 2: Determination of percentage area of voids in aggregate concrete masonry units (by paper indentation)

4) BS EN 772-13:2000, Methods of test for masonry units - Determination of net and gross dry density of masonry units (except for natural stone)

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

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.

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

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Masonry units test methods — Determination of compressive strength

1 Scope

This Draft Rwanda Standard specifies test methods for determining the compressive strength of masonry units.

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 and classification*

DRS 536, *Methods of test for masonry units — Part 16: Determination of dimensions*

ISO 6507-1, *Metallic materials— Vickers hardness test — Part 1: Test method*

RS 211-7, *Mortar for masonry — Part 7: Determination of water absorption coefficient due to capillary action of hardened mortar*

3 Terms and definitions

For the purposes of this standard, the following terms and definitions given inDRS 515 and ISO 6507-1and the following apply.

3.1

gross dry density

the mass per unit gross volume after drying to constant mass

3.1.2

gross volume

the volume of the unit derived from the length, width and height with a deduction of the volume of perforations, voids, recesses or indentations intended to be filled with mortar

3.1.3

net dry density

the mass per unit net volume after drying to constant mass

3.1.4

net volume

thegrossvolumeoftheunitlessthevolumeofanyperforationsorvoidsnotintendedtobefilledwithmortar.

4 Symbols (and abbreviated terms)

fb normalized compressive strength of masonry unit (N/mm^2)

d shape factor multiplier used to convert the air-dry compressive strength of the masonry specimens to the normalised compressive strength.

5 Principle

The specimens, after preparation, when needed, are laid and centred on the platen of a compression testing machine. A uniformly distributed load is applied and increased continuously up to failure.

6 Materials

Sand with a maximum grain size of 1 mm.

Cement

7 Apparatus

7.1 Testing machine that conforms to the requirements of Table 1.

Table 1 — Requirements for testing machines

Maximum permissible repeatability of forces as percentage of Indicated force %	Maximum permissible mean error of forces as percentage of Indicated force %	Maximum permissible error of zero force as percentage of maximum force of range %
2,0	±2,0	±0,4

The testing machine shall have adequate capacity to crush all the test specimens, but the scale used shall be such that the failure load on the specimen exceeds one-fifth of the full-scale reading. The machine shall be provided with a load-pacer or equivalent means to enable the load to be applied at the rate given in 9.2. The testing machine shall be equipped with two steel-bearing platens. The stiffness of the platens and the manner of load transfer shall be such that the deflection of the platen surfaces at failure load shall be less than 0,1 mm measured over 250 mm. The platens shall either be through hardened or the faces case hardened. The testing faces shall have a Vickers hardness of at least 600 HV when tested in accordance with ISO 6507-1.

One platen of the machine shall be able to align freely with the specimens as contact is made, but shall be restrained by friction or other means from tilting during loading. The other platen shall be a plane non-tilting block. The bearing faces of both platens shall be larger than the size of the largest specimen to be tested. Where auxiliary platens are used, they shall be properly located and of the same hardness, stiffness and planeness as the main platens. The bearing surfaces of the platens shall not depart from a plane by more than 0,05 mm.

7.2 Weighing instrument capable of weighing specimens to an accuracy of 0,1 % of their mass.

7.3 Sufficient stiff steel strips for use on shell bedded or strip bedded ground units (See 9.1).

8 Preparation of specimens

8.1 Sampling

The method of sampling shall be in accordance with the relevant product standard. The minimum number of specimens shall be six, but a larger minimum number may be specified in the product specification, in which case that larger number shall be used. In the case of large masonry units representative portions, e.g. cubes, may be cut from the masonry unit in different positions as stated in the relevant product standard (see also Note to 8.2.4).

8.2 Surface preparation

8.2.1 General

Specimens shall be tested in the orientation specified, and this shall be stated in the test report. For certain forms of construction, it will be necessary to test the masonry units in more than one orientation. Where grinding in accordance with 8.2.4 significantly alters the contact surface or reduces the height significantly alternative approaches are required, see 8.2.4. Where it is not practicable to prepare clay HD units by grinding e.g. high strength units, the surface preparation may be carried out by capping in accordance with 8.2.5

After the removal of any superfluous material, e.g. flashing from the production process, the faces of the specimen, whether a whole masonry unit or a piece cut from a larger unit (see 8.1), through which the load is to be applied, shall be plane to a tolerance of 0, 1 mm in any 100 mm and such that the top surface lies between two parallel planes which are parallel to the bottom surface, and not greater than 1 mm apart for every 100 mm. If the test faces of the masonry unit as manufactured, or the piece cut from a larger unit, fail to achieve this specification, then prepare the surfaces either by grinding (see 8.2.4) or by capping (see 8.2.5).

Masonry units containing frogs, and not required to be capped, shall additionally be treated as given in 8.2.3. If the specimens contain grooves or tongues first prepare them as given in 8.2.2. Test specimens shall be prepared in accordance with Annex B. State the method of surface preparation in the test report.

8.2.2 Removal of tongues and grooves

Remove any tongues and/or grooves on the test faces of units prior to testing. If pieces are to be cut from larger units, arrange the cutting so that any tongues and/or grooves are eliminated.

8.2.3 Preparation of masonry units containing frogs and which are not to be capped

For masonry units with frogs that are assessed to have a net loaded area of more than 35 % of the bed face test them without removing or filling the frogs. Where the net loaded area of masonry units with frogs is less than or equal to 35 % of the gross area then the frogs shall be filled with mortar of the same kind as used for capping (see 8.2.5) and the curing shall be carried out in accordance with the requirements of 8.2.5.4.

8.2.4 Grinding

Grind the surfaces of the specimen until the requirement for planeness and parallelism given in 8.2.1 is achieved. However, if the masonry units have frogs, indented lettering, cavities, perforations, internal or external holes, leave these in place. If the grinding process would significantly alter the contact area of the tested faces then the capping procedure of 8.2.5 shall be followed. If the remaining height of the specimens after they are ground is less than 40 mm or the height /width ratio less than 0,4, then make up a composite specimen by placing one upon the other without using any mortar or binding material or separating layer(s) between them.

NOTE Where a composite specimen is made up from more than one ground unit, this should be considered as a single

specimen providing a single test result. Accordingly, a greater number of masonry units than that specifically stated in 2801 will be necessary in order to provide the required number of test results.

8.2.5 Capping

8.2.5.1 Capping of masonry units without voids or with voids unfilled

Use a cement / sand capping mortar expected to attain a minimum compressive strength, when tested in accordance with RS 211, at the time of testing the specimens, at least that of the expected masonry unit strength or 30 N/mm^2, whichever is the lesser.

If necessary, e.g. for units with high water absorption characteristics, first moisten the surfaces to be capped. Bed each specimen on a smooth rigid plate of ground glass or stainless steel which does not depart from a true plane surface by more than 0, 1 mm in any 100 mm. A suitable method is as follows:

Support the plate firmly with the machined face uppermost and level it in two directions at right angles using a spirit level. Coat the plate with a film of mould release oil or a sheet of thin paper or plastic film to prevent mortar adhering to the plate. Place a uniform layer of mortar about 5 mm thick on the plate about 25 mm longer than the unit and about 10 mm wider. Press one bed face of the specimen firmly into the layer so that the vertical axis of the specimen is perpendicular to the plane of the plate.

Check this condition by using a square or spirit level held against each of the four vertical faces of the specimen in turn. Ensure that the thickness of the mortar bed is at least 3 mm over the whole area and that any cavity in the bed face normally filled when the masonry units are laid in the wall is completely filled with mortar. Do not fill cavities except for those that are intended to be filled in the construction. Trim off any surplus mortar flush with the sides of the masonry units.

Cover the specimen and mortar with a damp cloth. Keep the cloth damp. When sufficiently hardened, examine the mortar bed. If free from defects such as a lack of compaction, lack of adhesion to the masonry unit and/or cracking, bed the second bed face in the same way as the first, using mortar made with materials drawn from the same batches of cement and sand and using the same mix proportions.

After removing the specimen from the plate, check that the mortar bed is free from defects as before. Small holes may be made in the capping to drain water trapped in cavities, if necessary.

8.2.5.2 Capping of masonry units to be face-shell bedded

When masonry units are to be face-shell bedded in use and specimens are not to be prepared by grinding, bed each specimen in mortar as specified in 8.2.5.1 using the following procedure.

Support and coat the plate as described in 8.2.5.1. Lay two parallel strips of mortar about 5 mm thick such that each strip is about 25 mm longer than the length of the unit and about 10 mm wider than the face shell.

Press one bed face of the unit into the mortar such that the thickness of the mortar under the face-shells is at least 3 mm. Check that the vertical axis of the specimen is perpendicular to the plate using a square or vertical level check each vertical face.

Trim off any surplus mortar. Store the specimen, examine and bed the second face in accordance with 8.2.5.1 and 8.2.5.2 respectively.

8.2.5.3 Capping of masonry units to be strip-bedded

When masonry units are to be strip-bedded, the procedure specified in 8.2.5.2 shall be followed except that the capping mortar shall be applied to all of the surfaces to be bedded in use.

8.2.5.4 Storage of capped specimens

Cure the specimens under sacks kept damp throughout the curing period or store in a conditioning chamber at a relative humidity of greater than 90 %. Cure for a period sufficient to ensure the mortar achieves the minimum strength specified in8.2.5.1.

8.3 Conditioning of specimens before testing

8.3.1 General

Specimens shall be conditioned using a prescribed regime of moisture conditions or to a prescribed moisture condition as appropriate. The method of conditioning shall be as described in this clause. The method shall be as specified in Annex B. In all cases, except for conditioning by immersion, free air circulation around each specimen shall be ensured during conditioning.

8.3.2 Conditioning to the air-dry condition

The condition air dry will be achieved in accordance with one of the following procedures:

8.3.2.1 Store the specimens for at least 14 d in the laboratory at:

a) Temperature ≥ 15ºC

b) Relative humidity ≥ 65%

The specimens may be tested before 14 d if constant mass has been reached.

Constant mass shall be considered to have been reached if, during the drying process in subsequent weighing's with not less than a 24 h interval, the loss in mass between two determinations is less than 0,2 % of the total mass.

8.3.2.2 Dry the specimens at 105 °C ± 5 °C for at least 24 h and cool at room temperature for at least 4 h.

8.3.3 Conditioning to the oven dry condition

The condition oven dry will be achieved in accordance with one of the following procedures:

a) Dry the specimens at 105 °C ± 5 °C to constant mass. Constant mass shall be considered to have beenreached if, during the drying process in subsequent weighing's with not less than a 24 h interval, the loss in mass between two determinations is less than 0,2 % of the total mass. Allow the specimens to cool to ambient temperature before testing.

b) Dry the specimens at 70 °C ± 5 °C to constant mass. Constant mass shall be considered to have been reached if, during the drying process in subsequent weighing's with not less than a 24 h interval, the loss in mass between two determinations is less than 0,2 % of the total mass. After drying and prior to testing store the specimens at 20 °C ± 2 °C until thermal equilibrium is reached. After that, perform the test within 24 h.

8.3.4 Conditioning to 6 % moisture content

Condition the specimens to a moisture content of 6 % ± 2 % by mass as follows:

Calculate the dry mass ofthe unit from thevolume, which shall be calculated from the dimensions determined as in DRS 536 andthe drydensity determined in accordance with Annex C. The mass of the specimen at the time of testing shall be the dry mass multiplied by 1.06. Dry the specimens at a temperature not exceeding 50 °C until this mass is attained with an accuracy of ± 0.2 % of the dry mass.

After conditioning to the 6 % moisture content and prior to testing, store the specimens at room temperature for at least 5 h.

Check and record the mass of the specimen just before testing.

Determine the moisture content in accordance with Annex B.

8.3.5 Conditioning by immersion

Immerse thespecimens inwater at a temperature of 20 °C ± 5 °C for aminimum periodof 15h and subsequently allow them to drain for 15 min to 20 min.

8.4 Loaded area

8.4.1 Gross area

The gross area of the loaded surface shall be calculated in square millimetres by multiplying the length by the width of each specimen determined in accordance with DRS 536. Where units are to be tested with the compressive force other than normal to the bed face, then the gross area shall be calculated similarly but using the width and height or length and height as appropriate.

8.4.2 Net loaded area of units containing frogs intended to be filled with mortar in practice

Where the net loaded area of masonry units with a frog which is intended to be filled with mortar in practice (see also 7.2.3) is not less than 35 % of the gross area then the compressive strength shall be calculated on the basis of the net loaded surface of the frogged bed face. Where the net loaded area of masonry units with a frog is less than 35 % of the gross area then the compressive strength shall be calculated on the basis of the gross area of the masonry unit. In the case of units with frogs in both bed faces the net loaded area to be used shall be the smaller of the two.

Where the frog is of a regular shape, determine the frog area of each specimen by simple measurement and the principles of geometry. For rectangular frogs, determine the frog area of each specimen by measuring the length and width at the outer perimeter of the frog, using a rigid steel rule. Measurements shall be made to the nearest 1 mm. Calculate the net loaded area for each specimen as the difference between the gross area of the bed face and the frog area.

Alternatively, and for units possessing a non-regular frog shape, the net loaded area may be determined by a paper indentation method following the principles of Annex A.

9 Procedure

9.1 lacing specimens in the testing machine

Wipe the bearing surfaces of the testing machine (6.1) clean and remove any loose grit from the bed faces of the specimen. Align the specimen carefully with the centre of the ball-seated platen, so that a uniform seating is obtained. Units with a single frog shall be placed with the frog uppermost. Units with a frog in both bed faces shall be placed with the larger frog uppermost.

Do not use any packing material except for units intended to be face-shell bedded or strip-bedded and which have been prepared by grinding. In such cases position four stiff steel strips (6.3), the same width as the face• shells and 50 mm longer, two at the top and two at the bottom, overlapping equally at each end.

9.2 Loading

Initially, use any convenient rate of loading but, when about half the expected maximum load has been applied, adjust the rate so that the maximum load is reached in not less than approximately 1 min. Table 2 is given as a guide to choosing appropriate loading rates.

Record the maximum load achieved.

Table 2 — Loading rate

Expected compressive strength (N/mm^2)	Loading rate ($(N/mm^2)/s$)
< 10	0.05
11 to 20	0.15
21 to 40	0.3
41 to 80	0.6
> 80	1.0

NOTE With some specimens, the applied load may fluctuate several times before maximum failure load is reached. This will be indicated by a reduction in load as the specimen yields followed by an increase to a new maximum as loading is continued. This temporary reduction may occur several times before the specimen finally fails.

10 Calculation and expression of results

Calculate the strength of each specimen by dividing the maximum load achieved by its loaded area, which is the gross area for units intended to be laid on a full bed of mortar, to be face shell or strip bedded and those containing frogs not intended to be filled in practice, or in accordance with 7.4.2 in other cases, and express it to the nearest 0, 1 N/mm2.

11 Evaluation of results

The test report shall contain the following information:

a) number, title and date of issue of this Kenya Standard;

b) name of the organisation that carried out the sampling and the method used;

c) date of testing;

d) type, origin and designation of the masonry unit by reference to product standard;

e) number of specimens in the sample;

f) date of receipt of the specimens in the testing laboratory;

g) a sketch of the specimen, if needed, showing the extent of the loaded area and the height and the orientation of loading;

h) method of conditioning;

i) for those units conditioned to 6 %, the moisture content at the time of testing;

j) method of surface preparation used;

k) failure load in N, and measured dimensions in mm of each specimen;

l) strength of the specimens in N/mm2, to the nearest 0, 1 N/mm2, and the coefficient of variation of the sample to the nearest 0.1 %;

m) compressive strength of the sample in N/mm2, to the nearest 0, 1 N/mm2;

n) required the value of the normalised compressive strength (see Annex A) in N/mm2 to the nearest 0,1 N/mm2;

o) remarks, if any.

Annex A
(normative)

Determination of percentage area of voids in masonry units (by paper indentation)

A.1 General

This Annex gives a method of determining the percentage area of voids in masonry units.

A.2 Principle

After preparation of the specimens thick pieces of paper are impressed on the test surfaces1) of the masonry units and the indentation measured to give the percentage area of voids.

A.3 Symbols

A_v is the total cross-sectional area of voids (mm^2)

A_u is the cross-sectional area of masonry unit (mm^2)

M_{pv} is the mass of paper cut to the shape of the void (g)

M_{pu} is the mass of paper cut to the shape of the masonry unit (g)

A.4 Materials

Thick, stiff sheets of paper, the dimensions of each piece of paper exceeding the dimensions of the masonry unit by at least 20 mm in both directions.

A.5 Apparatus

A.5.1 Compression testing machine.

A.5.2 Planimeter.

A.5.3 Weighing instrument, capable of weighing to an accuracy of 0,1g.

A.6 Preparation of specimens

A.6.1 Sampling

The minimum number of specimens shall be six, but a larger minimum number may be specified in the product specification, in which case that larger number shall be used.

A.6.2 Surface treatment

Remove any roughness on the test face(s) of the masonry unit.

A.7 Test procedures

A.7.1 Obtaining the indentations

Place one sheet of paper on the bottom platen of a compression testing machine (A.5.1). Place the masonry unit on the paper, with the voids running vertically, and then, if required to test two faces simultaneously, place a second sheet of paper on the top face of the masonry unit. Apply a load of approximately 3 kN. Mark the outline on both sheets of paper of the indentations that have been made.

A.7.2 Measurement

A.7.3 General

Measure the areas of the cross-section of the voids and the masonry unit in accordance with A.7.2.2 or the weights of the corresponding areas of paper in accordance with A.7.2.3.

A.7.4 Measurement by geometry

For each sheet of paper determine the total cross-sectional area of the voids Av and of the masonry unit Au and express them to the nearest 10 mm^2 the planimeter (C.5.2).

A.7.5 Measurement by weight

For each sheet of paper cut out the area representing the area of the masonry unit and weigh it to the nearest 0.1g. Record the weight Mpu.

From the sheet of paper representing the area of the masonry unit cut out the areas representing the voids and weigh these to the nearest 0.2g. Record the weight M_{pv}.

A.8 Expression of results

Determine the percentage area of voids by:

Geometry: $\frac{A_v}{A_u} x\ 100$ (1)

Or by weight: $\frac{M_{pv}}{M_{pu}} x\ 100$ (2)

for the paper applied to each bed face of the masonry unit.

Determine the mean percentage area of voids, if required, to the nearest 1 %.

A.9 Test report

The test report shall contain the following information:

a) the number, title and date of issue of this Standard;

b) the name of the organization that carried out the sampling and the method used;

c) the date of testing;

d) the type, origin and designation of the masonry unit by reference to the product standard;

e) the number of specimens in the sample;

f) a reference to the method used (i.e.: by geometry or by weight);

g) the percentage area of voids of each specimen and the mean value, if required, to the nearest 1 %;

h) remarks, if any.

Annex B
(normative)

Determination of moisture content of calcium silicate and autoclaved aerated concrete units

B.1 General

This Annex gives a method for determining the moisture content of calcium silicate and autoclaved aerated concrete masonry units.

B.2 Principle

After drying to constant mass, the moisture content is calculated as the ratio of the loss of mass during drying to the mass after drying.

B.3 Symbols

w_s is the moisture content, in percentage by mass;

$m_{o,s}$ is the mass of specimen before drying, in grams;

$m_{dry,s}$ is the mass of specimen after drying, in grams

B.4 Apparatus

5.1 Ventilated oven, capable of maintaining a temperature of (105±5) °C.

5.2 Weighing instrument, capable of weighing specimens to an accuracy of at least 0.1 % of their mass.

B.5 Preparation of specimens

Take a representative sample of no fewer than six units. For units with lengths ≥ 500 mm and/or heights ≥300 mm, take no fewer than six representative portions cut from at least three units.

$$\rho \quad u \quad \frac{M}{V} \quad {}^{u}X \quad 6\,\frac{k}{m3}$$

B.6 Test procedure

Before drying, weigh the test specimens ($m_{o,s}$).

Dry the test specimens at a temperature of (105±5) °C,to constant mass. Constant mass is reached if, duringthe drying process, in two subsequent weighings with a 24 h interval, the loss in mass between the two determinations is less than 0.2 % of the total mass.After drying to constant mass, weigh the specimens (mdry,s).

B.7 Calculation and expression of results

Calculate the moisture content (w_s) of the specimen from the ratio of the loss in mass during drying to the dry mass, expressed as a percentage to the nearest 0,5 %.

$$w_s = \frac{m_{o,s} - m_{dry,s}}{m_{dry,s}} x\, 100$$

B.8 Evaluation of results

Calculate the mean value of the moisture content of the specimens to the nearest 1 %.

B.9 Test report

The test report shall contain the following information:

a) the number, title and date of issue of this Standard;

b) a description of the specimens to the relevant product standard;

c) the method of sampling, and by which organization;

d) the date of delivery of the specimens;

e) the date of preparation of the specimen and the date of testing;

f) the number of specimens in the sample, and whether these are whole units or representative portions thereof;

g) the individual values of moisture content to the nearest 0,5 % and the mean value of moisture content to the nearest 1 %;

h) remarks, if any.

Annex C
(normative)

Determination of net and gross dry density of masonry units (except for natural stone)

C.1 General

This Annex gives a method amethodofdeterminingthe netandgrossdrydensityofmasonryunits(exceptfornaturalstonemasonryunits).

C.2 Principle

After drying to constant mass and calculating the net and gross volume, the net and gross dry density of the masonry units are calculated.

C.3 Symbols

Grams

l_u is the unit length, (mm)

w_u is the unit width, (mm)

h_u is the unit height, (mm)

$m_{o,u}$ is the mass of a whole unit specimen prior to drying, (g)

$m_{o,p,tot}$ is the combined mass of a group of three representative portions of a whole unit specimen prior to drying, (g)

$m_{dry,p}$ is the mass of one individual representative portion of the three portions of a whole unit specimen after drying to constant mass, (g)

$m_{dry,p,tot}$ is the combined mass of a group of three representative portions of a whole unit specimen after drying to constant mass, (g)

$m_{dry,u}$ is the mass of a whole unit specimen (or corresponding whole unit where representative portions have been taken) after drying to constant mass, (g)

w_p is the moisture content of a group of three representative portions of a whole unit specimen

$v_{n,u}$ is the net volume of unit, (mm^3)

$v_{g,u}$ is the gross volume of unit, (mm^3)

$v_{g,p}$ is the gross volume of parts of unit, (mm^3)

$\rho_{n,u}$ is the net dry density, (kg/m^3)

$\rho_{n,p}$ is the net dry density of parts of unit, (kg/m^3)

$\rho_{g,u}$ is the gross dry density, (kg/m^3)

C.4 Apparatus

4.1 Ventilated oven, capable of maintaining a temperature of 105 °C ± 5 °C for use with clay, calcium silicate and autoclaved aerated concrete units.

4.2 Ventilated oven, capable of maintaining a temperature of 70 °C ± 5 °C for use with aggregate concrete and manufactured stone units.

4.3 Weighing instrument, capable of weighing the whole unit or portions of it to an accuracy of 0.1 % of their mass.

C.5 Sampling

The method of sampling shall be in accordance with the product standard. The minimum number of specimens shall be six, but a larger minimum number may be specified in the product specification, in which case that larger number shall be used.

C.6 Procedure

C.6.1 Determination of dry mass

C.6.1.1 Whole unit specimens

Dry the test specimens to constant mass $m_{dry,u}$ in a ventilated oven at a temperature of 70 °C ± 5 °C (6.2) for aggregate concrete and manufactured stone masonry units or 105 °C ± 5 °C (6.1) for clay, calcium silicate and autoclaved aerated concrete masonry units. Constant mass is reached, if during the drying process in two subsequent weighings with a 24 h interval, the loss in mass between the two determinations is not more than 0.2 % of the total mass. Record the mass $m_{dry,u}$.

C.6.1.2 Portions of whole unit specimens

Where representative portions are used, first weigh each whole unit specimen and record the mass ($m_{o,u}$). Then, obtain three representative solid portions, i.e. containing no enclosed or exposed formed voids, of at least 100 g from each whole unit specimen and weigh each group of three together. Record the mass of each group ($m_{o,p,tot}$).

Dry each group of three portions to constant mass following the procedure of C.6.1.1 above. Record the mass of each group ($m_{dry,p,tot}$).

Calculate the moisture content of each group of three portions using equation (1):

$$W_p = \frac{m_{o,p,tot} - m_{dry,p,tot}}{m_{dry,p,tot}} \qquad (1)$$

Calculate the corresponding dry mass of the whole unit ($m_{dry,u}$) using equation (2):

$$m_{dry,u} = \frac{m_{o,u}}{l + w_p} \qquad (2)$$

C.6.2 Netdrydensity

C.6.2.1 Wholeunits

Determinethenetvolumeusingoneofthefollowingmethodsasappropriate;

a) Forclaymasonryunits,byweighingin waterasindicatedinAnnex E

b) Forcalciumsilicatemasonryunits,byusingsandfillingasindicatedinAnnex D

c) For manufactured stone and solid aggregateconcretemasonry units,bysubtracting thevolumeofallrecesses orindentations, determined usingasuitablemeasuring device,fromthevolume(*lengthxwidthxheight*) determined inaccordance with DRS 536.ExpressthenetvolumeV$_{n,u}$tothenearest 10^4mm^3.

d) Foraggregate concretemasonryunitswithformedvoids,bythemethodofc)above,butinadditionsubtractingthevolumeofallvoids.ExpressthenetvolumeV$_{n,u}$tothenearest10^4mm^3.

Determinethenetdrydensityofthemasonryunit($\rho_{n,u}$)usingequation(3);

$$\rho_{n.u} = \frac{m_{dry,u}}{V_{n,u}}\, x\, 10^6 \left(\frac{kg}{m^3}\right) \qquad (3)$$

Calculate the net dry density of each whole unit specimen to the nearest 5 kg/m^3 for densities up to 1000 kg/m^3 and to the nearest 10 kg/m^3 for densities over 1000 kg/m3. Calculate the mean of the net dry densities of the specimens.

C.6.2.2 Representative portions of whole unit specimens

Determine the net dry density of the parts as follows:

a) Determine the dry mass of each portion of the whole unit specimen mdry,p by drying according to C.6.1.2;

b) Determine the volume of the parts $V_{g,p}$ by measuring length, width and height to the nearest 1 mm;

c) Calculate the net dry density $\rho_{n,p}$ to the nearest 5 kg/m^3 using equation (4):

Comment [SN1]: This reference is not available

Comment [AK2]: make this Annex E.

$$\rho_{n,u} = \frac{m_{dry,p}}{V_{g,p}} \, x \, 10^6 (\frac{kg}{m^3}) \qquad (4)$$

Define the net dry density of each whole unit specimen (from which the portions were obtained) as the mean value of the net dry density of the three representative portions. Express the net dry density of the whole unit specimens to the nearest 5 kg/m^3 for densities up to 1000 kg/m^3 and to the nearest 10 kg/m3 for densities over 1000 kg/m^3. Calculate the mean of the net dry densities of the whole unit specimens.

C.6.3 Gross dry density

Calculate the gross volume Vg,u of the unit from the unit dimensions length, width and height in accordance with DRS 536 with a subtraction of the volume of perforations, voids, recesses or indentations intended to be filled with mortar determined by measurement by any suitable method with the same accuracy of measurement as incorporated in DRS 536. To find the gross dry density of the unit (ρg,u) [see equation (5)], divide the dry mass ($m_{dry,u}$) obtained according to C.6.1 by the gross volume ($V_{g,u}$) of the unit:

$$\rho_{G,u} = \frac{m_{dry,p}}{V_{g,u}} \, x \, 10^6 (\frac{kg}{m^3}) \qquad (5)$$

Express the gross dry density of each whole unit specimen to the nearest 5 kg/m^3 for densities up to 1000 kg/m^3 and to the nearest 10 kg/m^3 for densities over 1000 kg/m^3. Calculate the mean of the gross dry densities of the specimens.

C.7 Test report

The test report shall contain the following information:

a) the number, title and date of issue of this Standard;

c) a description of the masonry unit to the relevant product standard

d) the method of sampling and by which organization;

e) date of receipt of the specimens by the test laboratory;

f) the date of testing the specimens;

g) the number of specimens in sample and whether these are whole units or representative portions thereof;

h) the individual and mean values of net dry density;

i) the individual and mean values of gross dry density; and

j) remarks, if any.

Annex D
(normative)

Determination of volume and percentage of voids and net volume of clay and calcium silicate masonry units by sand filling

D.1 General

This Annex gives a method of determining the volume and percentage of voids and net volume of calcium silicate masonry units containing cells, frogs and holes.

D.2 Principle

The principal of this test is to measure the volume of voids in a masonry unit by measuring the volume of sand required to fill them.

D.3 Symbols

$V_{n,u}$ is the net volume of each unit (10^4 mm^3),

$V_{s,u}$ is the volume of voids (10^4 mm^3),

$V_{g,u}$ is the gross volume of each unit (10^4 mm^3),

D.4 Materials

Dry graded sand with a grain size above 0.5 mm and passing a 1 mm test sieve (D.5.4).

D.5 Apparatus

5.1 Thin sheet of foam rubber, or other resilient material.

5.2 Rigid plate, slightly larger than the unit.

5.3 Glass measuringcylinder, graduated in ml.

5.4 Two test sieves, one with 0.5 mm apertures and one with 1 mm apertures.

D.6 Preparation of specimens

D.6.1 Sampling

The method of sampling shall be in accordance with the relevant product standard. The minimum number of specimens shall be six, but a larger minimum number may be specified in the product specification, in which case that larger number shall be used.

D.6.2 Surface treatment

Remove any superfluous material adhering to the unit as a result of the manufacturing process before commencing the test.

$$\rho \quad u \quad \frac{M}{V} \quad {}^{u}X \quad 6 \ \frac{k}{m3}$$

D.7 Test procedure

D.7.1 Volume of voids

Place the air-dry unit on the thin sheet of foam rubber (D.5.1) or other resilient material with the open end of voids uppermost. When the unit has voids or recesses in the ends that need to be measured, close the ends with the rigid plate (D.5.2).

D.7.2 Sand filling procedure

Fill the glass measuring cylinder (D.5.3) accurately with the dry sand and record the volume. Fill the voids with the sand by pouring from the cylinder, refilling it if required. Keep the cylinder lip as close as possible to the top of the void, pour steadily and then strike off level.

Return to the cylinder any sand struck off and note the total volume of sand ($V_{s,u}$) used to the nearest 104 mm3.

D.8 Calculation and expression of results

Calculate the gross volume of the unit (*Vg,u*) by multiplying the length (l_u) by the height (hu) and the width (Wu) of the unit measured in accordance with DRS 536.

$V_{g,u} = l_u \times W_u \times H_u$ (1)

Calculate the net volume (*Vn,u*) of each unit to the nearest 10^4 mm^3, if required.

$V_{n,u} = V_{g,u} - V_{s,u}$ (2)

Calculate the net volume ($V_{n,u}$) of each unit to the nearest 10^4 mm^3, if required.

$$V_{n,u} = \frac{V_{s,u}}{V_{s,u}} x\ 100 \qquad (3)$$

D.9 Evaluation of results

Calculate the mean value of the water absorption of the specimens to the nearest 0.1 %.

D.10 Test report

The test report shall contain the following information:

a) the number, title and date of issue of this Standard;

b) a description of the specimens to the relevant product standard;

c) the method of sampling, and by which organization;

e) the date of preparation of the specimen and the date of testing;

g) the number of specimens in sample;

h) the net volume of each specimen and the mean value to the nearest 10^4 mm^3;

i) the percentage of voids of each specimen and the mean value, if required, to the nearest 1%; and

h) remarks, if any.

Annex E
(normative)

Determination of net volume and percentage of voids of clay masonry units by hydrostatic weighing

E.1 Principle

The principle of this test is to obtain the net volume of the masonry unit by weighing in air and weighing in water and to subtract this from the gross volume, obtained by measurement of its dimensions, to obtain

The volume of voids.

E.2 Symbols

Mwu is the apparent mass of the specimen in water (g).

Mau is the mass of the specimen in air (g).

lu is the length of the specimen (mm).

wu is the width of the specimen (mm).

hu is the height of the specimen (mm).

Vgu is the gross volume of the specimen (mm3).

Vvu is the volume of voids in the specimen (mm3).

Vnu is the net volume of the specimen (mm3).

rw is the density of water (g/mm3) (approx. 0,001 g/mm3).

E.3 Apparatus

5.1 Tank, with adequate capacity to submerge a whole masonry unit.

5.2 Weighing instrument, capable of weighing whole masonry units with an accuracy of at least 0,1 % of their mass when dry.

E.4 Sampling

The method of sampling shall be in accordance with product standards. The minimum number of specimens shall be six, but a larger minimum number may be specified in the product specification, in which case that larger number shall be used.

E.5 Test procedure

Measure the length (lu), width (wu) and height (hu) of the specimen in accordance with DRS 533 .

Immerse the specimen in water (5.1) for at least 1 hour. When the apparent masses (Mwu), measured by two successive weighings at 30 min intervals, differ by less than 0,2 % remove the specimen from the water and record the result of the second weighing as the apparent mass (Mwu). Remove surface water with a damp towel and determine the weight (Mau) immediately.

E.6 Calculation and expression of results

Calculate the net volume of the specimen (Vnu) by subtracting the mass of the specimen obtained by weighing it under water from that obtained when weighing it in air (Mau 2 Mwu) and dividing it by the density of water (rw). Express the net volume of the specimen to the nearest 104 mm3 as

Determine the mean value of net volume determinations to the nearest 104 mm3.

Calculate the gross volume of the specimen (Vgu) bymultiplying the length (lu) by the height (hu) andwidth (wu) of the specimen measured in accordancewith DRS 533 to the nearest 104 mm^3.

$$V_{gu} = l_u \times w_u \times h_u \qquad (2)$$

Calculate the volume of voids (V_{vu}) by

$$V_{vu} = V_{gu} - V_{nu} \qquad (3)$$

Calculate the percentage of voids to the nearest 1 % by

$$\frac{V_{vu}}{V_{gu}} \times 100\,\% \qquad (4)$$

Determine the mean value, if required, to the nearest 1 %.

E.79 Test report

The test report shall contain the following information:

a) the number, title and date of issue of this Rwanda Standard;

b) the name of the organization that carried out thesampling and the method used;

c) the date of testing;

d) the type, origin and designation of the masonryunit

e) the number of specimens in sample;

f) the net volume of each specimen and the meanvalue to the nearest 104 mm3;

g) the percentage of voids of each specimen and themean value, if required, to the nearest 1 %;

h) remarks, if any

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