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Mortar for masonry — Test methods —

Part 5:

Determination of flexural and compressive strength of hardened mortar

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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 211-5 was prepared by Technical Committee RSB/TC 009, *Civil engineering and building materials.*

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

1) BS EN 998-1: 2016, *Specification for mortar for masonry — Part 1: Rendering and plastering mortar*

2) BS EN 998-2: 2016, *Specification for mortar for masonry — Masonry mortar*

3) BS EN 1015-2:1999+A1: 2006, *Methods of test for mortar for masonry – Part 2: Bulk sampling of mortars and preparation of test mortars*

4) BS EN 1015-3: 1999, *Methods of test for mortar for masonry – Part 3: Determination of consistence of fresh mortar (by flow table)*

5) BS EN 1015-11:2019, *Methods of test for mortar for masonry – Part 11: Determination of flexural and compressive strength of hardened mortar*

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

This second edition cancels and replaces the first edition (RS 211-5: 2010), clauses 6, 7, 9, Table 1, Figures 1 and A.1 and Annex A, of which have been technically revised.

DRS 211 consists of the following parts, under the general title *Mortar for masonry — Test methods*:

— *Part 1: Determination of particle size distribution (by sieve analysis)*

— *Part 2: Bulk sampling of mortars and preparation of test mortars*

— *Part 3: Determination of consistence of fresh mortar (by flow table)*

— *Part 4: Determination of consistence of fresh mortar (by plunger penetration)*

— *Part 5: Determination of flexural and compressive strength of hardened mortar*

— *Part 6: Determination of adhesive strength of hardened rendering and plastering mortars on substrates*

— *Part 7: Determination of water absorption coefficient due to capillary action of hardened mortar*

Committee membership

The following organizations were represented on the Technical Committee on *Civil engineering and building materials*(RSB/TC 009) in the preparation of this standard.

Advanced Construction Technology Services (ACTS) - Rwanda

CIMERWA

City of Kigali

Green Pact Africa

Rwanda Inspectorate, Competition and Consumer Protection Authority (RICA)

RTDA

Standard Geotechnical Engineering and Construction Ltd (STAGECO Ltd)

SJEC Ltd

UR-CST

Rwanda Standards Board (RSB) – Secretariat

Mortar for masonry — Test methods — Part 5: Determination flexural and compressive strength of hardened mortar

1 Scope

This Draft Rwanda Standard provides a method for determining the flexural and compressive strength of moulded mortar specimens.

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 211-1, *Mortar for masonry — Test methods — Part 1, Determination of particle size distribution (by sieve analysis)*

DRS 211-2, *Mortar for masonry — Test methods — Part 2: Sampling of mortars and preparation of test mortars*

DRS 211-3, *Mortar for masonry — Test methods — Part 3: Determination of consistence of fresh mortar (by flow table)*

RS 108*, Mortar for masonry— Specification*

3 Terms and definitions

For the purposes of this standard, the following term and definition apply.

air-lime

lime mainly consisting of calcium oxide or hydroxide which slowly harden in air by reacting with atmospheric carbon dioxide. Generally, they do not harden under water as they have no hydraulic properties.

4 Principle

The flexural strength of mortar is determined by three points loading of hardened moulded mortar specimens to failure. The compressive strength of the mortar is determined on the two parts resulting from the flexural strength test. Where the flexural strength is not required, the parts for compressive strength testing can be produced from the specimens in any way which does not lead to these parts being damaged.

5 Apparatus

5.1 Metal moulds, consisting of an open frame of removable walls forming three compartments when assembled (see Figure 1 for typical design and annex A for a detailed description).

5.2 A tamper, consisting of a rigid, non-absorptive rod of square cross-section, each side of which is 12 mm + 1 mm. The tamping face is flat and at right angles to the length of the tamper. The mass of the tamper is 50 g + 1g.

5.3 Storage chambers, capable of maintaining a temperature of 20 °C (+3 °C/-2 °C)and a relative humidity of 95 % + 5 % or 65 % + 5 %.

5.4 A clamp, enabling the assembled mould frames to be kept together at right angles.

5.5 White cotton gauze, four sheets each with a size of approximately 150 mm x 175 mm.

5.6 Absorbent filter paper, with a specific mass of 200 g/m2 + 20 g/m2 and water absorption capacity of 160 g/m2 + 20 g/m2; twelve sheets each with a size of approximately 150 mm + 175 mm.

5.7 Polyethylene bags, capable of containing the steel moulds.

5.8 Two glass plates, of sufficient area to cover the steel mould.

5.9 A palette knife.

5.10 A grid, with webs of triangular section providing point contact support for storing and curing the specimens.

5.11 A trowel

Additional apparatus is described in 8.1 and 9.1.

6 Sampling

6.1 General

6.1.1 The fresh mortar for this test shall have a minimum volume of 1.5 L or at least 1.5 times the quantity needed to perform the test, whichever is the greater, and shall be obtained either by reduction of the bulk test sample (see DRS 211-2) using a sample divider or by quartering, or by preparation from dry constituents and water in the laboratory. Two test samples shall be prepared.

6.1.2 The mortar shall be brought to a defined flow value as specified in DRS 211-2 determined in accordance with DRS 211-3 or DRS 211-4 and reported.

6.1.3 Before testing, the batch shall be gently stirred by hand using a trowel or palette knife in 5 s to 10 s to counteract any false setting, etc., but without any additional mixing of the batch.

6.2 Laboratory prepared mortars

6.2.1 The length of the mixing period shall be measured from the moment all the constituents are introduced into the mixer. The test procedure shall start after mixing but shall be concluded within the specified workable life of the mortar (preferably within 30 min after completion of mixing).

6.2.2 Any deviation from the mixing procedure shall be noted.

6.3 Mortars, other than laboratory prepared mortars

Ready to use mortars (factory-made wet mortars which are retarded), and pre-batched air-lime/sand wet mortars when not gauged with hydraulic binders, shall be used for specimen preparation within their specified workable life.

7 Preparation and storage of test specimens

7.1 General

The test specimens shall be specimens of 160 mm x 40 mm x 40 mm. Three specimens shall be provided. For the compressive strength test, break the specimens into two halves to provide six half specimens.

7.2 Preparation

7.2.1 General

7.2.1.1 Prepare mortars based on hydraulic binders (retarded or not retarded), and air-lime/cement mortars with mass of air-lime not exceeding 50 % of the total binder mass, in accordance with 7.2.2.

7.2.1.2 Prepare mortars based on air-lime, and air-lime/cement mortars with cement mass not exceeding 50 % of the total binder mass, in accordance with 7.2.3.

7.2.1.3 Preparation and storage conditions are given in Table 1.

7.2.1.4 Prepare three specimens for testing at an age of 28 days, or more if retarding agents are incorporated in the mortar, unless otherwise specified.

7.2.1.5 Clean the moulds and lubricate the internal faces of the assembled moulds with a thin layer of mineral based oil that does not affect setting of mortars, to prevent adhesion of the mortar.

7.2.2 Mortars with hydraulic binders, and air-lime/cement mortars with mass of air-lime not exceeding 50 % of the total binder mass

7.2.2.1 Fill the mould with mortar in two approximately equal layers, each layer being compacted by 25 strokes of the tamper. Alternatively, the mould may be tilted through approximately 30° and tapped ten times, returned to the horizontal and then tilted and tapped a further ten times. The method of compaction shall be reported.

7.2.2.2 Skin off the excess mortar with a palette knife, leaving the mortar surface plane and level with the top of the mould. Then store the mould as described in 7.3**.**

7.2.3 Mortars based on air-lime, and air-lime/cement mortars with cement mass not exceeding 50 % of the total binder mass

7.1.3.1 Place the assembled mould frame, clamped together at right angles, on a glass plate on which two layers of dry white cotton gauze have been placed. Fill the mould with mortar in two approximately equal layers, each layer being compacted by 25 strokes of the tamper. Alternatively the mould may be tilted through approximately 30° and tapped ten times, returned to the horizontal and then tilted and tapped a further ten times. The method of compaction shall be reported.

7.1.3.2 Skim of the excess mortar with a palette knife leaving the mortar surface plane and level with the top of the mould.

7.1.3.3 Place two layers of white cotton gauze tightly on the mortar surface. Place six layers of absorbent filter paper on top of the gauze.

7.1.3.4 Cover the absorbent filter paper with a glass plate and turn the mould upside down keeping the glass plates at the bottom and top firmly attached to the mould.

7.1.3.5 Carefully remove the glass plate from the top of the inverted mould, place six layers of absorbent filter paper on the exposed gauze and re-cover with the glass plate on top.

7.1.3.6 Re-invert the mould back to its upright position and place it on a fixed table and load with mass of approximately 5 kg.

7.1.3.7 After 3 h remove the load and the glass plate. Discard the absorbent filter paper and the gauze on top of the mould, and re-cover with the glass plate on top. Invert the mould, keeping the non-absorptive plates at the bottom and the top firmly attached to the mould. Remove the non-absorptive plate from the top of the Inverted mould and discard the absorbent filter paper and the gauze. Then store the mould as described in 7.3.

7.3 Storage and curing conditions

7.3.1 Mortars with hydraulic binders, and air-lime/cement mortars with mass of air-lime not exceeding 50 % of the total binder mass.

Place the mould in a humidity chamber or in sealed polyethylene bags. Then after the period given in Table 1 remove the specimens from the mould and subsequently store them on a metal grid under the conditions also described in Table 1

7.3.2 Mortars based on air-lime, and air-lime/cement mortars with cement mass not exceeding 50 % of the total binder mass.

Place the mould in the storage chamber. Then after five days remove the specimens from the mould and subsequently store them on a metal grid under the conditions described in Table 2.

Table 1 — Preparation and conditions of storing specimens for mortars in accordance with 7.3.1

Type of mortar	Preparation	Storage time at a temperature of 20 °C (+3°C /- 2 °C in days		
		Relative humidity		
		95 % ± 5 % or in polyethylene bag		65 % ± 5 %
		In the mould	With the mould removed	With the mould removed
Cement and air-lime/cement mortars with mass of air-lime not exceeding 50 % of the total binder mass	7.2.2	1-3	until a total of 7 days in the storage chamber or polyethylene bags	21
Mortars with other hydraulic binders	7.2.2	1-3		21
Retarded mortars	7.2.2	7	-	21

Table 2 — Preparation and conditions of storing specimens for mortars in accordance with 7.3.2

Type of mortar	Preparation	Storage time at a temperature of 20 °C (+3°C /- 2 °C in days		
		Relative humidity		
		95 % ± 5 % or in polyethylene bag		65 % ± 5 %
		In the mould	With the mould removed	With the mould removed
Air-lime mortars	7.2.3	5	2	21
Air-lime/cement mortars with cement mass not exceeding 50 % of the total binder mass	7.2.3	5	2	21

Additionally, testing can be performed after an extended 90-day cure under the conditions defined in Table 2 (7 days at 95 % relative humidity followed by 83 days at 65 % relative humidity). The alternative curing period shall be clearly identified.

8 Determination of flexural strength

8.1 Apparatus

8.1.1 A testing machine, capable of applying the load at a rate specified in 8.2. The machine shall comply with the requirements in Table 3. The machine shall have two steel supporting rollers of length between 45 mm and 50 mm and 10 mm ± 0.5 mm diameter, spaced 100.0 mm ± 0.5 mm apart, and a third steel roller of the same length and diameter located centrally between the support rollers (see Figure 1)

8.1.2 The three vertical planes through the axes of the three rollers shall be parallel and remain parallel, equidistant normal to the direction of the specimen under test. One of the supporting rollers and the loading roller shall be capable of tilting slightly to allow a uniform distribution of the load over the width of the specimen without subjecting it to any tensional stresses.

Dimensions in millimetres

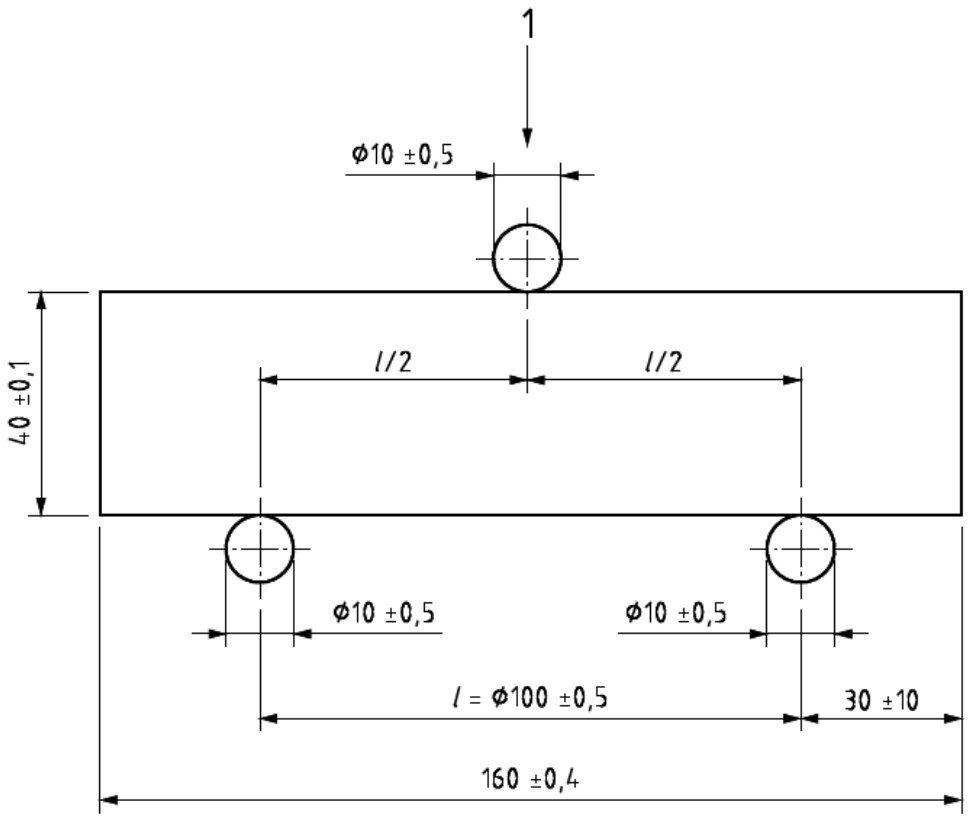

Figure 1 — Flexural strength test

where

1 Load

l is the distance between the axes of the support rollers, in millimetres (mm)

Table 3 — Requirements for testing machines

Maximum permissible repeatability of forces as percentage of nominal force	Maximum permissible means error of force as percentage of nominal force	Maximum permissible error of zero force as percentage of maximum force of range
±2.0	±2.0	± 0.4

8.2 Procedure

8.2.1 Preparation

Test the specimen at 28 days after casting, or more if retarding agents are incorporated in the mortar, unless otherwise specified, and immediately after removing from the storage atmosphere. Wipe the bearing surfaces of the roller and the sides of specimen with a clean cloth to remove any loose grit or other material. Place the specimen with one of its faces (which has been cast against the steel of the mould) on the supporting rollers.

8.2.2 Loading

Apply the load without shock at a uniform rate in the range 10 N/s to 50 N/s so that failure occurs within a period of 30 s to 90 s.

NOTE A loading rate at the lower end of the permitted range may need to be used for the lower strength mortars.

Record the maximum load applied, in N. Return the broken specimen to the storage chamber and keep it there if required, for compressive strength measurements.

8.3 Calculation and expression of results

8.3.1 Calculate the flexural strength, f, in N/mm^2 using the following equation:

$$f = 1.5\frac{\mathrm{Fl}}{\mathrm{b}d^2}$$

where

F is the maximum load applied to the specimen, in Newtons (N);

l is the distance between the support rollers, in millimetres;

b is the width of specimen in millimeters (mm);

d is the depth of the specimen in millimeters (mm).

8.3.2 b and d may be taken as the internal mould dimensions.

8.3.3 Record the flexural strength of each specimen to the nearest 0.05 N/mm^2. Calculate the mean to the nearest 0.1 N/mm^2.

8.3.4 Record age of test specimen and age at demoulding.

9 Determination of compressive strength

9.1 Apparatus

9.1.1 **A testing machine**, capable of applying the load at a rate specified in 9.2.2. The machine shall comply with the requirements in Table 3. The upper machine platen shall be to align freely as contact is made with the specimen, but the platens shall be restrained from tilting with respect to one another during loading.

9.1.2 **Two bearing plates**, made of tungsten carbide or of steel of surface hardness at least 600 HV Vickers hardness value. The plates shall be 40.0 mm long X 40.0 mm ± 0.1 mm wide and 10 mm ±0.1mmthick. The dimensional tolerance for the width shall be based on the average of four symmetrically placed measurements. The flatness tolerance for the contact faces shall be 0.01 mm.

9.1.3 **Compression jig**, used to facilitate the location of the bearing plates. The base plate of the jig shall be of hardened and tempered tool steel and the faces shall have a flatness tolerance of 0.01 mm. A device to provide positive centring on the lower platen of the testing machine shall be provided. Hardened and tempered silver steel pillars shall be symmetrically placed about the cantering device so that the gap in one direction is the nominal width of the prism plus 0.3 mm and in the other direction is the nominal width of the prism plus 0.8 mm. The top face of the base plate shall be marked with an arrow in the direction of the greater distance between the pillars to indicate the direction of the long axis of the bearing plates.

9.2 Procedure

9.2.1 Preparation

9.2.1.1 Test the specimen at 28 days after casting, or more if retarding agents are incorporated in the mortar, unless otherwise specified, and immediately on removing from the storage atmosphere or after the flexural strength test. Remove any loose grit or other material from the sides of the specimen as cast. Wipe the bearing surface of the testing machine, and the bearing plates and jig, with a clean cloth and place the specimen in the machine in such a manner that the load is applied to one of its faces (which has been cast against the steel of the mould).

9.2.1.2 Arrange the prism so that the cast end is 16 mm ± 0.1 mm from the nearer edge of the platens or bearing plates. Discard any specimens that do not provide a cube of solid material between the top and bottom platens or bearing plates. Carefully align the specimen so that the load is being applied to the whole width of the faces in contact with the platens. When using the bearing plates and jig, place one bearing plate on the upper surface of the jig with its long axis parallel to the indicating arrow, ensuring that it makes close contact over the whole surface.

9.2.1.3 Place the specimen in the jig, between the pillars, with its long axis perpendicular to the arrow and place the other bearing plate on top of the specimen parallel to the lower bearing plate. Carefully centre the compression jig assembly on the lower platen of the test machine.

9.2.2 Loading

9.2.2.1 Apply the load without shock and increase it continuously until failure occurs. As a guide suggested loading rates are given for the different classes of masonry and rendering mortars in Annex B.

9.2.2.2 Record the maximum load applied, in N, during the test.

9.3 Calculation and expression of results

9.3.1 Calculate the strength as the maximum load carried by the specimen divided by its cross-sectional area of the bearing plate (nominally 1600 mm^2).

9.3.2 Record the strength of each specimen to the nearest 0.05 N/mm^2; calculate the mean to the nearest

0.1 N/mm^2.

9.3.3 Record the age of specimens and the age at demoulding.

9.4 Test report

The test report shall include the following information:

a) the place, date and time of taking the bulk test sample;

b) the method used for taking the bulk test sample (if known) and the name of the organization that took it;

c) the type, origin and designation of the mortar by reference to the relevant standard;

d) the date of testing;

e) preparation (mixing, casting) and storage (curing) conditions;

f) the date and time of preparing samples for test (i.e. date and time of any mixing, casting, demoulding, or demoulding procedure, if appropriate);

g) the flow value of the test mortar determined in accordance with DRS 211-3;

h) age of mortar when tested;

i) test results (individual values of flexural strength, if required, and of the compressive strength of mortar stated to the nearest 0.05 N/mm^2, and corresponding mean value stated to the nearest 0.1 N/mm^2;

j) j) remarks, if any.

NOTE The is the sample taken from the bulk supply that is to be used for all of the tests in RS 211

Annex A
(normative)

Description of metal moulds for specimen preparation

A.1 General

A.1.1 The compartment walls are at least 8mm thick and rigid enough to prevent distortion or damage to specimens on removal.

A.1.2 The assembled mould frame is firmly attached to a rigid base plate by means of a fixing screw arrangement thus giving a water-resistant joint when greased (see 7.2.2), or it may be held together at right angles by means of a clamp and firmly placed on a loose glass plate thus forming the bottom of the mould (see 7.2.3).

A.1.3 A typical mould design for prism specimens is shown in Figure 1

A.1.4 The assembled moulds conform to the following requirements:

a) **Dimensions**: For each compartment, the internal dimensions are: length 160mm ±1mm; depth 40mm±0.1mm and width 40mm±0.2mm. .

b) **flatness**: the surface of each internal face lies between two parallel planes 0.03 mm apart. The joints between the sections of the mould and between the bottom surface of the mould and the top surface of the base plate shall lie between two parallel planes 0.06 mm apart.

c) **squareness**: the surface of each internal face lies between two parallel planes 0.50 apart, which are perpendicular to the bottom surface of the mould and also to the adjacent internal faces.

d) **parallelism**: the top surface of the mould lies between two parallel planes 1.0 mm apart and is parallel to the bottom surface.

e) **surface texture**: the surface texture of each internal surface shall be not greater than 3.2 mm R_a.

Dimensions in millimetres

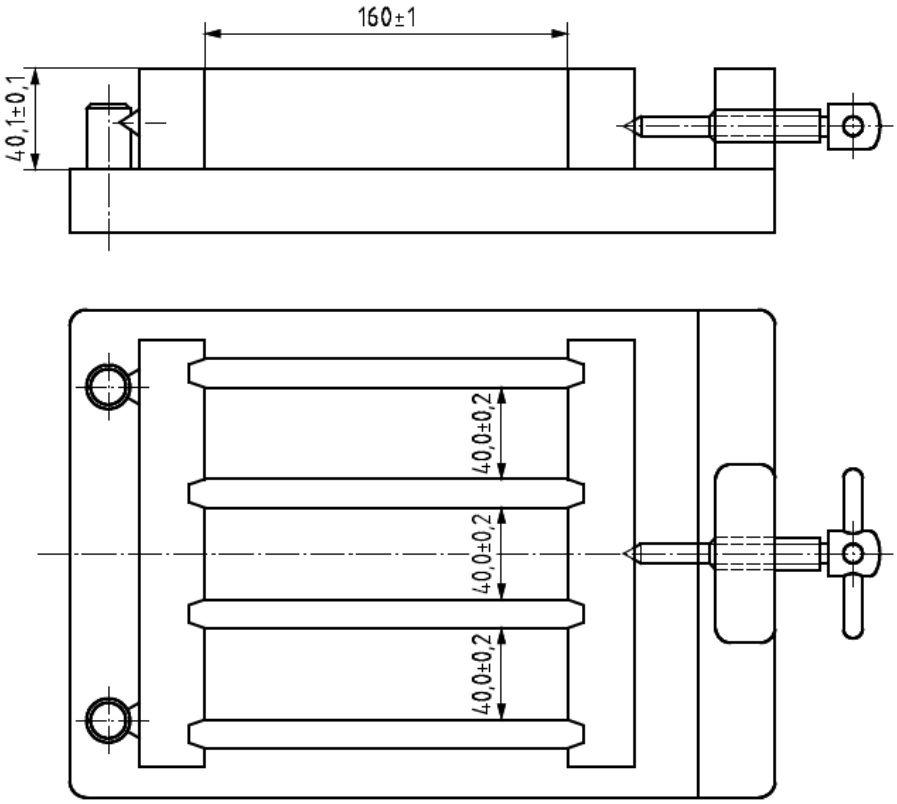

Figure A.1 — Mould for forming test specimens

Annex B
(normative)

Suggested loading rates for different classes of masonry and rendering mortars

Suggested loading rates for different classes of masonry and rendering mortars, in N/s, are given in Table B.1.

Table B.1 — Suggested loading rates

Masonry mortars			**Rendering mortars**	
Category	Compressive strength (N/mm^2)	Loading rate (N/s)	Category	Loading rate (N/s)
M20	20	400	CS I	400
M 15	15	400	CS II	200
M 10	10	400	CS III	100
M 5	5	200	CS IV	50
M 2.5	2.5	100	-	-
M 1	1	50	-	-

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