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RILEM TC 127-MS: TESTS FOR MASONRY MATERIALS AND STRUCTURES

RILEM TECHNICAL COMMITTEES

Recommendations

Foreward:
The texts presented hereunder are drafts for general consideration. Comments should be sent to the Secretary:
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MS-D.7 Determination of pointing hardness by pendulum hammer

D.7.0 CONTENTS

D.7.1 SCOPE

This recommendation specifies a method of determining the hardness of jointing and pointing mortars as a measure of overall quality. Measured hardnesses can be expressed in terms of hardness classes.

The method can be used *in situ* both for quality control purposes and as a means for trouble shooting. It can also be used in the laboratory using masonry panels, *i.e.* for control of hardness development during curing and hardening, or as a monitoring/control parameter for acid rain and freeze-thaw tests. The method of interpretation should take into account the type of mortar, *e.g.* opc, opc/lime, lime, aerated.

The method is <u>not</u> suitable for the following applications:

1) measuring absolute strength values.

2) testing mortars with large amounts of crystallized soluble salts in the surface layers.

3) testing weak lime mortars which give results below the range of optimum sensitivity.

D.7.2 SPECIMENS

Preferably measurements shall be performed on areas or panels no smaller than 0.5 x 0.5 m^2 and no larger than 1 x 1 m^2.

D.7.3 CONDITIONING OF SPECIMENS

Ideally measurements shall be made on air dry masonry. For the purposes of field tests, this is defined as masonry which has not been wetted in the past 24 hours and which gives visually the impression of being dry (*i.e.* has some suction).

If measurements are made in order to follow the development of hardness of jointings/pointings, all measurements shall be made on masonry which is of similar moisture content. Samples should be taken to measure the moisture content where possible, *e.g.* using the drilling technique given in RILEM test MS.D.10 [4] or in Annex 1 of RILEM test MS.D.1 [5].

D.7.4 APPARATUS

The apparatus to be used is the so called Schmidt Prüfhammer PM (Schmidt Pointing Hardness Tester PM), produced and marketed by PROCEQ SA in Zurich, Switzerland. See Fig. 1.

The apparatus shall be provided with a measuring head having a cylinder-like shape with a diameter of 8.0 mm and being rounded at the measuring end with a diameter of 8.0 mm and a dome with a 1.0 mm rise.

D.7.5 PROCEDURE

Fig. 1 illustrates the device in use.

• Press the apparatus in a vertical position and with the center of the circular opening in the foot of the apparatus on the center line of the joint with the right hand firmly against the masonry to be measured.

• First determine the so-called zero fault by letting the measuring head rest freely against the joint. Note the scale value. Do this at five points regularly divided over the area tested.

• If zero values greater than +5 are being determined, then the sole of the pointing hardness tester shall be brought a few millimetres from the masonry using a flat slab of a suitable material. Next determine the pointing hardness.

Fig. 1 – Pointing hardness tester in use.

• Place the measuring head with the left hand in the upright position using the lever on the measuring head.

• Press the knob next to the thumb of the right hand.

• Read the recoil value on the scale.

• Perform nine measurements uniformly divided over the area to be judged, *e.g.* three times three measurements horizontally and vertically at one third from the boundaries of the area or the edges of the panel to be measured.

Table 1 - Pointing hardness classification

Class	Hardness	Indicated quality
0 (zero)	<15	very soft
A	15-25	soft
B	25-35	moderate
C	35-45	normal
D	45-55	hard
E	> 55	very hard

D.7.6 TEST RESULTS

Determine the median of the nine recoil values per area. The median value is the fifth value when the four lowest or the four highest values are being deleted (*i.e.* the middle value of the set of nine).

Determine the median of the five zero fault values as either a negative, zero or positive number.

Subtract the median zero fault from the median of the pointing hardness. Corrections for the zero fault can be made from - 5 to + 5 scale values. Express the results in terms of the classes given in Table 1.

Example:

Recoil value = 30, zero fault value = - 4, Corrected value = 30 - (- 4) = 34

Recoil value = 30, zero fault value = + 4, Corrected value = 30 - (+ 4) = 26

D.7.7 TEST REPORT

1) A reference to this method.

2) A description of the masonry including the size of the area(s) or the panel(s) tested;
   the type and size of the brick;
   the height and width of the joints;
   the date of erection of the brickwork;
   relevant data, *e.g.* hardening conditions.

3) All individual measurements with an indication of their location, preferably in order of increasing values.

4) Moisture content of the masonry being measured.

D.7.8 BIBLIOGRAPHY

[1] van der Klugt, L. J. A. R., 'The pointing hardness tester - an instrument to meet a need', *Mater. Struct.* **24** (1991) 471-476.

[2] van der Klugt, L. J. A. R., 'The IBBC-TNO pointing hardness tester', TNO report BI-89121a (TNO Building and Construction Research, Delft, The Netherlands, 1989).

[3] van der Klugt, L. J. A. R., 'The IBBC-TNO pointing hardness tester', in Proceedings of the International Workshop 'Evaluation and Strengthening of Existing Masonry Structures', Padua, June 1995.

[4] RILEM Recommendation MS-D.10, 'Measurement of moisture content by drilling', *Mater. Struct.* **30** (200) (1997) 327-328.

[5] RILEM Recommendation MS-D.1, 'Measurement of mechanical pulse velocity for masonry', *Mater. Struct.* **29** (1996) 463-466.

MS-D.9 Determination of mortar strength by the screw (helix) pull-out method

D.9.0. CONTENTS

D.9.1 SCOPE

This recommendation specifies an *in-situ* method of testing jointing and pointing mortars. The technique can give useful data on the following characteristics:
1) Batch-to-batch variability of strength or general quality.
2) Variation of quality in relation to a reference sample.
3) Changes of properties with time, *i.e.* strength increases due to hardening and the effects of weather conditions and additives.
4) Absolute values of mortar cube strength, provided a suitable calibration data-base is available.

Thus, on building sites the method has application both for quality control purposes and as a means for trouble shooting. In the laboratory, it is useful for control of hardness development during curing and hardening, or as a monitoring/control parameter for other tests such as acid rain and freeze-thaw tests.

The method is limited by the yield strength of the helical steel screws used to a maximum strength of approximately 8 N/mm^2. Above this strength, the failure is by yield of the steel and the test value is no longer proportional to the strength of the mortar. Thus, for stronger mortars the technique is only suitable for proof testing. The method is not suitable for mortar beds less than 8 mm thick.

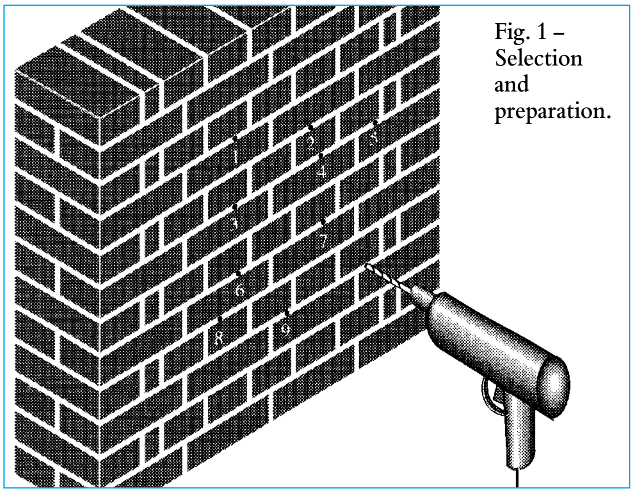

Fig. 1 – Selection and preparation.

D.9.2 SPECIMENS

Preferably measurements are performed on areas or panels ranging from 1 x 1 m^2 up to 1 x 2m^2, but smaller areas may be used where appropriate for specific investigations. Ten or more replicate measurements distributed randomly over the test area are normally taken for each determination. A clear depth of 35 mm is required for the standard determination, but other depths could be used for particular applications, *e.g.* 20 mm for testing pointing mortar. The strength at different depths can be tested by drilling oversize access holes and then carrying out the standard procedure. For any given determination all the measurements should be made at the same nominal depth of embedment of the helix and separate calibration data would be required for each embedment depth.

D.9.3 CONDITIONING OF SPECIMENS

Ideally, measurements shall be made on air dry masonry. For the purposes of field tests, this is defined as masonry which has not been wetted in the past 24 hours and which gives visually the impression of being dry (*i.e.* has some suction). Pore moisture or free water is likely to have a significant effect on the measurement and thus the moisture content should be measured in critical cases, *e.g.* using the drilling technique MS-D.10 [1].

D.9.4 APPARATUS

The basic apparatus to be used is the Helifix 6 mm diameter Retro-tie, together with a driving tool shown in Fig. 2. This is a commercial product, but it has been established that it is not possible to produce an alternative non-commercial version at a reasonable cost. Other equipment required is as follows: a 4.5 mm diameter drill bit fitted to a domestic capacity hammer-action drill to form the pilot hole, a tie gripper system and a pull-out force measuring unit. The reaction points or ring on the pull-out system should be sufficiently far from the axis of the tie to ensure that the pull-out mechanism is not influenced.

D.9.5 PROCEDURE

Fig. 1: Randomly select positions within an area not exceeding 2 m^2, and at each position drill a 4.5 mm diameter hole in the middle of the thickness of the mortar bed. Reject holes where the hole is significantly off-centre and too close to the unit, or where the drill drops into an obvious air void before reaching at least 30 mm depth. Add new locations if necessary until at least ten positions have

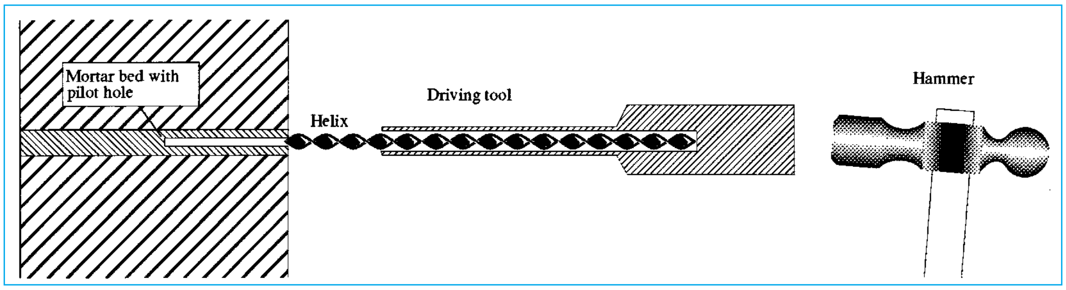

Fig. 2 – Positioning the tie.

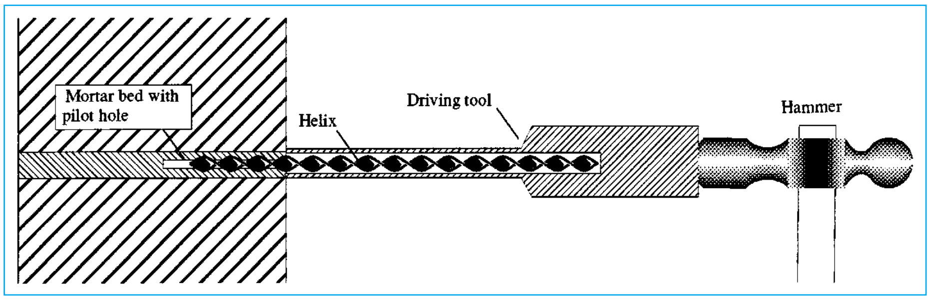

Fig. 3 – Installing the tie.

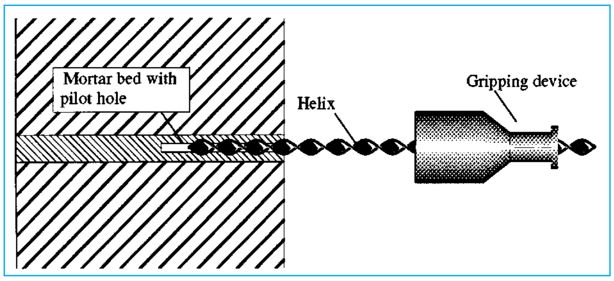

Fig. 4 – Attaching gripping device.

been prepared. Mark each position with a number and identify the area using chalk or a marker pen, then take a record photograph or make a sketch of the layout.

Fig. 2: Mount a helical tie into the driving tool and then, holding the sleeve of the tool horizontal, push the exposed end of the tie gently into the pilot hole.

Fig. 3: Hammer the helical tie firmly, but not violently, into the hole so that the specified length of its thread (L) is embedded in the mortar using the sleeved driving tool shown. This allows the tie to rotate and cut a thread in the mortar during insertion and is dimensioned to install the correct length. (The ties have a lead-in pointed tip about 5 mm long to facilitate theadcutting, thus the total depth of insertion is *circa* L + 5mm). Note: experience has shown that L = 30mm gives the best results for homogeneous mortar with no pointing layer.

Fig. 4: After installation, a gripper is then screwed onto the end of the tie. This holds the tie fixed during the test, restraining it from rotating, and ensures a shear type failure in the test material.

Fig. 5: The proof loading device is then attached to the gripper and the assembly is rotated to screw down the tie and take up any slack. The tie is loaded until failure. The load applied to the tie should be increased steadily. The peak load reached during a test is held by the dead needle on the dial, and is recorded as the pull-out load.

Two distinct types of reaction frame can be used: one with a number of individual legs that react against the test material, and the other with a steel ring providing the contact with the material's surface. The type with legs tends to be lighter and easier to use and can be left attached to the test unit. The reaction points or ring should be at least 30 mm, and ideally 50 mm, away from the axis of the tie to avoid restraining the mortar under testing.

D.9.6 TEST RESULTS

Where the data is used to indicate/monitor quality variation, to follow changes due to hardening or cyclic actions in durability testing, it is sufficient to calculate the mean of the ten (or more) measurements.

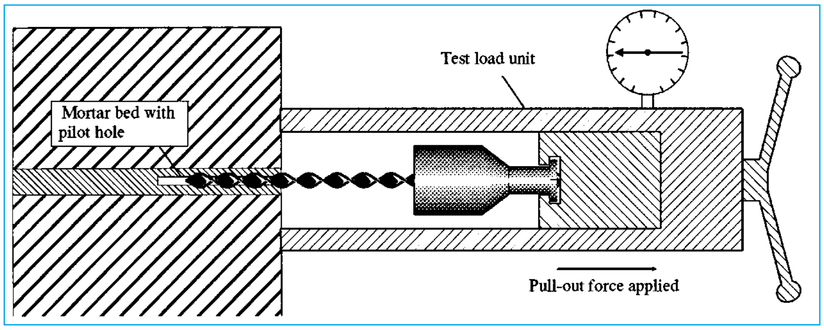

Fig. 5 – Load testing the tie.

If absolute indications of equivalent strength properties such as cube strength, flexural strength or tensile strength are required, the data must be transformed using a suitable calibration curve. Previous calibration trials indicate that the relationship between pull-out force and strength properties is not linear, thus each individual measurement must be transformed before the mean is calculated. Examples of calibration data for cube strength are given in the Bibliography.

D.9.7 TEST REPORT

1) A reference to this method.
2) A description of the masonry including the size of the area(s) or the panel(s) tested;
   the type and size of the brick;
   the height and width of the joints;
   the date of erection of the brickwork;
   the nominal specification of the mortar (if known);
   other relevant data, *e.g.* hardening conditions.
3) The moisture content of masonry being measured, where critical.
4) All individual measurements with an indication of their location.
5) The mean of individual measurements or the mean of equivalent strength values as required.

D.9.8 BIBLIOGRAPHY

[1] RILEM Recommendation MS-D.10 'Measurement of moisture content by drilling'. (See below).
[2] de Vekey, R.C., '*In-situ* tests for masonry', Proc. 9th Intl. Brick and Block Mas. Conf., V1 (1991) 621-627.
[3]Ferguson, W.A. and Skandamoorthy, J. S., 'The screw pull-out test for the *in-situ* measurement of the strength of masonry materials', Proc. 10th Intl. Brick and Block Mas. Conf., Calgary, V3 (1994) 1257-1266.

MS-D.10 Measurement of moisture content by drilling

D.10.0 CONTENTS

D.10.1 SCOPE/PRINCIPLE

Small quantities of dust and debris are removed from the specimen (structure or material) by drilling. The dust is weighed then dried to constant weight in an oven at 100°C. The weight loss represents the weight of water or any other volatile compound absorbed in the pore structure of the specimen. The method will give poor accuracy in the following circumstances:
1) Where there is significant contamination by volatile compounds other than water and the composition ratio is unknown.
2) Where the masonry is near saturation, causing loss of free water as the solid material is broken down.
3) In very hard masonry where the rate of penetration of the drill bit is less than 2 mm/sec.

D.10.2 SPECIMENS

At least two, and preferably five or more, replicate drillings should be taken to represent a given material or zone of a structure. The variation of moisture content with depth may be obtained by separating the drilling dust into multiple samples representing increments of depth of the drill.

D.10.3 CONDITIONING OF SPECIMENS

The technique is for site or laboratory use. On site, no special preparation is necessary, but it is clearly unsatisfactory to carry out the tests during or soon after very heavy rainfall unless the effect of the rainfall is of interest. For laboratory tests, the conditioning should be as specified.

D.10.4 APPARATUS

A power drill (normal or percussive) with a selectable speed of 1200 ± 100 rpm. Sharp 8 mm diameter (= 5/16") 150mm long (= 6") tungsten carbide tipped drill bits. A collecting device which is either held in place or temporarily attached just beneath the drill hole. A balance accurate to 0.01 g. An oven.

D.10.5 PROCEDURE

Hold or attach the dust collector to the masonry at 25 ± 10 mm below the position selected for the the hole. Starting with the drill-bit at room temperature, drill a hole horizontally to a sufficient depth to give a representative sample. The drill should be hand held and sufficient pressure should be applied to give a rate of penetration of 2 mm/second or faster. Allow the drill bit to cool between each measurement or cool it by dipping into methylated spirits and then allowing the alcohol to evaporate to speed up the process. Change the collector at set depth intervals if a depth profile is required. Weigh each specimen of dust, then dry to constant weight in the oven. Fig. 1 illustrates the specimen gathering process.

D.10.6 TEST RESULTS

For each individual determination, report the percentage moisture content by mass as the weight change on drying divided by the dry weight multiplied by 100. Calculate the mean of replicate specimens.

D.10.7 TEST REPORT

1) A reference to this method.
2) A description of the masonry, including the identity of the building, size of the area(s) or the panel(s) tested, the size of the brick, the height and width of the joints and, where known, the type of the brick, the date of erection of the brickwork, the nominal specification of the mortar.

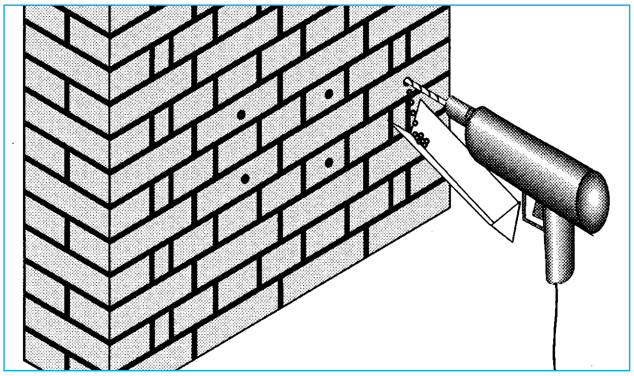

Fig. 1 – Typical drilling / collection procedure.

4) All individual measurements with an indication of their location.
5) The mean of individual measurements and the calculated moisture content as required.

D.10.8 BIBLIOGRAPHY

[1] Newman, A.J., 'Improvement of the drilling method for the determination of moisture content in building materials', Current Paper CP22/75 (Building Research Establishment, UK, 1975).
[2] Newman, A.J., 'The measurement of moisture in building materials', *Building Materials* (Jan/Feb 1975) 32-34.
[3] Binda, L., Squarcina, T. and Van Hees, R., 'Determination of Moisture Content in Masonry Materials: Calibration of Some Direct Methods', 8th Int. Congr. Deterioration and Conservation of Stone, Berlin, Vol.I (1996) 423-435.