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RILEM TC 177-MDT: 'Masonry durability and on-site testing'

RILEM Recommendation MDT. D.3 – Determination "in situ" of the adhesive strength of rendering and plastering mortars to their substrate

The texts presented hereunder are drafts for general consideration. Comments should be sent to the Chairperson Prof. Luigia Binda, Dipartmento di Ingegneria Strutturale, Politechnico di Milano, Piazza Leonardo da Vinci, 32, I-20133 Milano, Italy; Fax (+39) 02 23994220, Email: luigia.binda@polimi.it, by 28 February 2005.

0. SUMMARY

There is an enduring interest in the durability of masonry acting as a composite material especially because a very large proportion of the world's heritage buildings and civil engineering structures are predominantly constructed from this material. There is a continuing need for information on the best way to maintain a state of good preservation of masonry and on sympathetic techniques for repair and reinstatement of deteriorated masonry.

In order to evaluate materials for use in both new and old structures, laboratory accelerated durability tests are necessary. Equally, a range of in-situ, non-destructive or semi-invasive tests are required to evaluate the status and condition of structures in the field and allow quality control of repair systems.

1. SCOPE

This recommendation specifies a method for the determination "in situ" of the adhesive strength between rendering and plastering mortars and the substrate to which they are applied. The test is applicable as either a quality control technique for new rendering coatings on new or old structures or as an evaluation test in cases where failure (delamination, hollowness, spalling or cracking of renders) has occurred on a built structure.

Note: This proposition is based on the principles of the ***prEN 1015-12: Methods of test for mortar for masonry – determination of the adhesive strength of hardened rendering and plastering mortars on substrates*** [1, 2]*, with modifications for determinations "in situ" and on ancient buildings.*

2. PRINCIPLE

The adhesive strength is determined as the maximum tensile stress applied by a direct load perpendicular to the surface of the rendering or plastering mortar on a substrate. The tensile load is applied by means of a defined pull-head plate glued to the test area of the mortar surface, and the adhesive strength obtained is the ratio of the failure load to the test area.

3. SPECIMENS

3.1 General

The determinations must be performed in an area representative of the area to be tested. So, determinations should not be carried out very close to edges or windows/doors or on singular points of the walls or ceilings. The façade orientation, the age, the existence of recent renovation work and any other factors that can influence adhesion, are also to be taken into account when selecting the measuring points. Ambient conditions should be adopted but, for external renderings, it is inadvisable to carry out such work in intense sunlight, at very low temperatures (under 0ºC), in heavy rain or any other conditions likely to cause serious fluctuations in the state of the specimens or the instrumentation during the test duration.

3.2 Details of specimens

Circular areas of approximately 50 mm in diameter shall be cut through the mortar layer using a core drilling machine. Water-lubricated coring machines may cause less damage but the render must be allowed to dry out before the plate is attached and before a test s carried out. The core must reach the substrate, and, ideally, penetrate 1 or 2 mm into the substrate. The render in real buildings may vary from around 3 up to 100mm thick so a pilot core may be necessary to establish the penetration depth.. The diameter of the circular area for each specimen shall be recorded. Damaged specimens, namely specimens that lose adherence (shear off) or lose large pieces of the surface area (> 10%) during the cut, shall be rejected.

In cases where the bond might fail due to the applied torque of the coring machine an alternative technique using a rotary abrasive saw to cut a square of equivalent area using four intersecting cuts may be employed. The pull-head plates will also need to be square for this option.

3.3 Number of specimens

A test set shall consist of at least six specimens. This number must be enlarged when there is a considerable heterogeneity of the mortar or of the substrate or when any other conditions arise that can increase variability and make conclusions difficult.

3.4 Strength range

The test will work reliably over an adhesion strength range between 0.2 and 50 N/mm^2.

4. APPARATUS AND PRINCIPLE OF OPERATION

1) **Circular pull-head plates**, made of stainless steel, with diameter of 50 mm ± 0.1 mm and minimum thickness of 10 mm.

These plates shall have a central fitting for connection to the direct pull tensile force apparatus. A square plate of approximately equivalent area would be 45mm x 45mm.

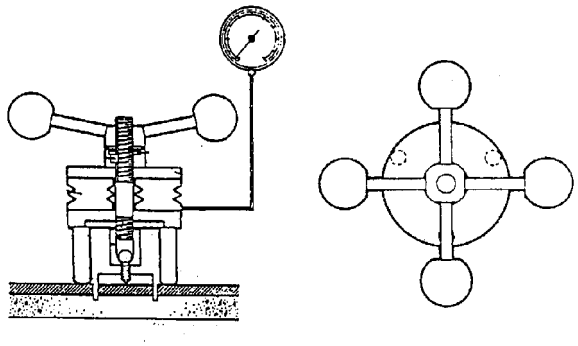
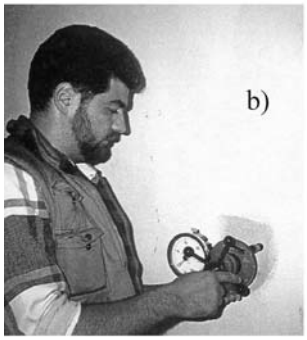


Fig. 1 - Apparatus for adhesion test.



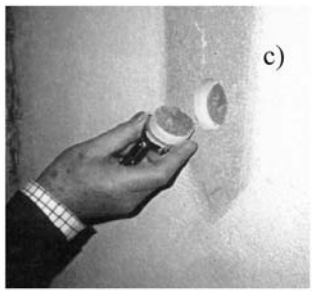


Fig. 2a - In-situ cutting in progress.
Fig. 2b - Adhesion test.
Fig. 2c - View of the specimen after test.

2) **Adhesive** based on resin, *e.g.* epoxy resin or methylmethacrylate resin.

3) Core **drilling machine,** with core drill of nominally 50 mm internal diameter, suitable to cut core samples from hardened mortars and substrates. This machine shall have a device to secure it to the wall or ceiling, using vacuum pads. It shall have adjustable speed and low vibration and it shall transmit the force perpendicularly to the test surface, without torque. The machine is illustrated by Fig. 2a.

4) Testing **machine for direct pull tensile force test** with suitable capacity and sensitivity for the test as specified in clause 5 and capable of applying the load to the pull-head plate through a suitable fitting that excludes any bending forces. A diagram of the device is shown in Fig. 1 and the apparatus is shown in use in Fig. 2b. The machine shall comply with the requirements in Table 1.

Table 1 - Requirements for testing machine

Maximum permissible repeatability of forces as percentage of nominal force (%)	Maximum permissible mean error of forces as percentage of nominal force (%)	Maximum permissible error of zero forces as percentage of maximum force of range (%)
2.0	± 2.0	± 0.4

5. PROCEDURE

The test shall be done in two phases (see Fig. 2):

1. Cut the circular specimens as specified in 3.2 and glue the pull-heads with the adhesive, centrally on the test areas, preventing any excess adhesive from bridging the cut around the test areas. Let the adhesive dry for 2 days. (While the adhesive is drying, fix the pull-heads, for instance with adhesive tape). *(NOTE. methyl methacrylate dental cement is available that may allow same-day testing)*

2. Apply the tensile load perpendicular to the test area through the pull-head plates by means of the testing machine. The load shall be applied without shock and at a uniform rate so that the stress increases within the range of 0.003 N/(mm^2.s) to 0.100 N/(mm^2.s), according to the expected adhesive strength, so that failure occurs between 20 s and 60 s (see Table 2). Record the failure load. Reject any test where the mode of failure is fracture at or close to the adhesive layer between the pull-head plate and the mortar.

Table 2 - Loading rate

Expected adhesive strength (N/mm^2)	Loading rate (N/mm^2.s)
< 0.2	0.003 - 0.010
0.2 – 0.5	0.101 – 0.025
0.5 – 1.0	0.025 – 0.050
> 1.0	0.050 – 0.100

6. TEST RESULTS

Calculate the individual adhesive strength from the following formula to the nearest 0.05 N/mm^2:

$f_u = W_u/A$

(f_u – adhesive strength in N/mm^2; W_u – failure load in N; A – test area of cylindrical specimen in mm^2)

Calculate the adhesive strength as the mean value from the individual values of the set of specimens (6 or more), to the nearest 0.1 N/mm^2.

Possible fracture patterns leading to valid results are the following:

1 Fracture pattern ***a***: Adhesion fracture – fracture at the interface between mortar and substrate;

2 Fracture pattern ***b***: Cohesion fracture – fracture in the mortar itself;

3 Fracture pattern ***c***: Cohesion fracture – fracture in the substrate material;

where fracture patterns ***b*** or ***c*** occur, results shall be considered as lower bound values and valid for calculation of the mean value of adhesive strength.

7. TEST REPORT

The test report shall provide the following information:

1 reference to this recommendation;

2 description of the site and in particular of the wall or ceiling to test and the place selected to cut the test areas;

3 type and description of the substrate;

4 date and time of testing (both phases);

5 climatic conditions at the time of testing;

6 details of test specimens, including number, dimensions, etc.;

7 individual values of adhesive strength rounded to the nearest 0.05 N/mm^2;

8 a description of mode of failure for each individual result, using the terminology referred at 6 together with remarks, if any;

9 the mean value of valid individual results rounded to the nearest 0.1 N/mm^2.

ACKNOWLEDGMENT

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