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SIMPLE FIELD TESTS IN STONE CONSERVATION

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Abstract

The field of stone conservation has been experiencing a huge growth in the last decades, partly due to a rising attention of scientists from different disciplines towards Cultural Heritage. In this context, several high tech techniques, set up originally for specific scientific questions or industrial applications, have been used and sometimes adapted to in-situ studies of stone monuments and objects. Although very valuable because generally non-destructive, and sometimes highly instructive, these techniques cannot be employed in many cases, because they are too expensive, not usable directly by practitioners or simply because they are not available at all on a given site. These are the reasons why simple field tests, which answer some of the basic questions the practitioner has on sites, should be better known. In the following paper a small selection of simple field tests - drop-test, resonance pointer, brush-test and strip-test - is presented by listing the necessary equipment, and detailing their procedure. The reader will also get information on how the test results can be interpreted, on what the tests could be useful for, and he will find some advises on what the main errors to be avoided are. The initiative on rising awareness about applications and limitations of simple field tests is linked to a will to initiate the formation of a group of volunteers wishing to validate, promote, teach and disseminate these techniques to a broad community.

Keywords: Field test, simple equipment, drop test, strip test, resonance pointer, brush test

1 Introduction

Three main questions have to receive an answer when assessing the condition of a monument (Cather 2003).

- is there a problem?
- is it active?
- what is its cause?

To answer these questions the monument or parts of it are first visited, observed, mapped. In a second step analyses are performed with mobile analytical instruments, and/or samples are collected for laboratory analysis, all with the aim to investigate the causes of the degradations. Finally the results of the investigations are interpreted in terms of intervention plans aiming at extending the service life of the monument.

During these investigations simple field tests can be very helpful, when large surfaces and many individual spots have to be characterized quickly to get an overview of the total situation on hand.

It is important to be aware that although the procedure to perform such field tests is usually easy and simple the interpretation is not necessarily so and “simple” should not be confused with “simplistic”! In that respect simple field tests do not differ from any other investigation. This also means that in the same way as other methods of scientific investigation, the procedure for simple field tests needs to be learned properly and the quality of the interpretation of the results depends to a certain extent on the experience of the operator implementing them. It is therefore very advisable to exercise those tests intensively on material with known properties to get familiar with the manipulations as well as the possible results.

No matter what method used, scientific investigations need to be adapted to the questions to be answered. Hence some investigations can be resolved by simple observations whereas others need the use of sophisticated machines. In the field of stone conservation observation always seems to be one of the first steps, be it to describe the material types (see e.g. Franzen, 2002), the deterioration patterns (ICOMOS-ISCS, 2008/2010) or to inspect the occurrence of microbiological growth as indicator for excess of water input or constructive faults (Lisci et al., 2003).

In the following paper a small selection of simple field tests is presented by listing the necessary equipment, and detailing their procedure. The reader will also get information on how the test results can be interpreted, some notion what the tests could be useful for, and some advises on what the main errors to be avoided are. Finally we provide some literature for further reading.

Before performing the field tests it is very important to recall that in some cases they can be destructive and hence should only be applied on materials and surfaces that can bear them without being damaged. E.g. the use of water or other liquids can lead to dissolution of sensitive materials or it can induce colour changes. In case of doubt the effects of the tests should be tested on comparable, non-problematic surfaces or materials. Not mentioned in each of the test descriptions is the detailed documentation necessary for all testing and intervention on Cultural Heritage (Venice Charter, ICOMOS, 1964).

2 Some Examples of simple field tests

In the following chapter, three simple field tests - drop-test, resonance pointer, brush-test and strip-test - are presented.

2.1 Drop tests

2.1.1

2.1.2 2.1.1. Water drop test

Aim of the test:

The water drop test is especially suitable to investigate whether an unpolished stone, mortar or matt painted surface is water repellent or not (Bläuer Böhm, 2007).

Materials needed to perform the water drop test:

- Small dropping container: it may be a plastic or glass dropping bottle. Alternatively a thin glass rod, a syringe fitted with a Teflon needle, or any other instrument allowing to produce small drops (such as Eppendorf micropipette) of even size can be used. The drops volume should not exceed 5 to 10 µL.
- Demineralized water to fill the dropping container
- If the results are to be quantified a stop watch is needed.

Figure 1. Water drop test performed on a water repellent surface (Photo Christine Blauer).

Test procedure, observations and interpretation:

A small drop of water is carefully applied on the surface of the material to be tested (figure 1). The development of this drop with time is observed. Usually one of the following behaviours can be observed:

- The drop forms a nearly perfect spherical shape on a horizontal surface and cannot be applied to a vertical surface because it immediately rolls off - the surface is highly water repellent
- The drop forms a spherical calotte with a contact angle that is 90° or bigger - the surface is water repellent

- The drop penetrates quickly forming a much bigger wet patch on the surface than the diameter of the initial drop – the outer surface of the material is not (any more) water repellent but underneath there is a layer of material that does not allow water to be sucked up well, either because it is still water repellent (for the way of aging of water repellent treatments in general see Charola, 2003 and under UV-light see Brezesinski and Mögel, 1993) or because it is impervious.
- The drop penetrates into the material forming a wet patch that is not much bigger than the initial drop size on the surface – the material is porous and capillary and not water repellent (e.g. many sandstones, limestones and mortars)
- The drop spreads on the surface without any noticeable penetration into it – the material is wettable but impervious (e.g. very dense limestones, marble)

To quantify the observations a stop watch can be launched at the moment when the drop initially touches the surface and the time until the drop is completely absorbed by the material can be measured. The time of complete absorption can usually be recognised by the wet surface loosing its glossy aspect. To produce values that are representative for a certain surface about 10 measurements should be made and then their mean value should be calculated.

Caution / mistakes to avoid:

It is important not to forget, that the size of the applied drop is dependent on the instrument used to apply it (Brezesinski and Mögel, 1993) - a bottle with a big neck will produce a big drop and vice versa, therefore it is best to always use the same bottle.

Temperature of the air or of the surface, sunshine, wind and other climatic conditions may strongly influence the measurement. Therefore only measurements performed under similar climatic conditions can be compared directly.

Visual fissures, even if they are very small, will increase the water suction speed of the surface drastically. This has also to be taken into consideration when using this test. Of course a fissured surface can be tested if the intention of the operation is to observe the difference to the non fissured material.

Some microorganisms, especially during the dry seasons, reduce the wettablity of the material surfaces strongly. This has to be taken into consideration, when choosing the surface spot where the test should be performed. And of course such a surface can be selected intentionally for the test to show the effect of microbiological growth.

Microdrops do not behave in the same way on vertical and horizontal surfaces, owing to gravity. It is recommended to select horizontal surfaces for implementing the test. If only vertical surfaces are available, devices producing very little (and thus lighter) drops will give better results.

The most frequent error in practice when testing surfaces for their water repellency seems to be, that instead of testing the surface by gently applying a small water drop, literally "buckets" of water are thrown at the surface. With big amounts of water even a water repellent surface will appear wet, especially if the surface is weathered and the outer most millimeters of the materials have lost their initial water repellent properties. (Bläuer Böhm, 2005).

2.1.3 Drop test with non polar liquids

For any test using whatever liquid it is important to consider before the test whether the surface is altered by the selected liquid. In case of doubt on valuable surfaces the reaction between the liquid and the material should be tested on a non problematic place.

A similar test as the water drop test can also be performed using non polar liquids like alcohol or white spirit. Except for the liquid, the equipment needed to perform the test is the same as for the water drop test.

Aim of the test:

On water repellent surfaces, this test can be used to find out whether the pores of the material are actually blocked or whether only the inner pore surfaces of the materials are coated, to inhibit their wetting by polar liquids such as water (Carmeliet et al., 2002), which is the most frequent case on water repellent treated surfaces (Charola 2003).

The test can also be used to estimate the potential uptake of a consolidation product in its initial, liquid, state. Especially so, if the liquid used for the test is chosen to have similar physical properties to the ones of the consolidant. If two neighbouring materials show very different capillary suction, they will also show a high difference in uptake of the consolidation product. If these particularities are known before the beginning of the treatment, the application procedure for the consolidant can be adapted accordingly.

Measurements of the suction speed of various liquids cannot be compared directly with one another, because their relevant physical properties (their wetting angle on a given surface material and their surface tension) are different. As an example the size of the drop forming on a given size of bottle neck at a given temperature will be directly proportional to the surface tension of the liquid (Brezesinski and Mögel, 1993). The above mentioned non polar liquids evaporate much quicker than water, which makes it difficult to observe the wet area produced by them.

2.1.3. Further reading on drop tests

A water drop test to perform in the laboratory is given by RILEM 25-PEM (1980). Further information on the test can be found in the paper by Rolland et al. (2012), in this volume.

The physico-chemical laws playing their part in the investigations with drop tests of water or other liquids can be found in Adamson (1990) and the same laws applied to building materials are explained in a very comprehensive way by Jeannette (1997). Brugnara et al. (2004) give an exhaustive insight into the application of the contact angle measurements when testing monumental surfaces.

Only a little more sophisticated approaches for the evaluation of water uptake in stone or mortar material are Karsten, Mirowski and contact sponge measurements (Wendler and Snethlage 1987, Vandevoorde et al. 2009, D'ham et al. 2011, Ferrerira et al. 2011).

2.2 Resonance pointer

Aim of the test:

The test aims at detecting detachments beneath the surface of an artifact.

Materials needed to perform this test:

- a rigid ca. 50 cm rod or an expandable antenna fitted at one end with a stainless steel ball about 2 cm in diameter.
- alternatively a metal wire (ca. 3mm diameter) bow or a small (size 6 or smaller) Allen key® can be used.

Figure 2. Resonance Pointer, Görlitz, Heiliges Grab, Germany (photo Christoph Franzen).

Test procedure:

The resonance pointer is hold by the extremity of its rod, and its ball is gently moved over the surface. The changing sound of the resonance induced by the instrument as it moves over the surface is listened to. The sound will differ according to the density of the surface. Subsurface detachments induce the production of sounds with lower frequencies which appear to the ear as “hollow” sounds.

Caution / Mistakes to avoid:

It has to be noted first that this test can only be performed on stable and or not valuable surfaces. Surfaces with wall paintings or remaining traces of polychromies usually limit the use the test as described here. In these cases gentle tapping with the fingers or with very light instruments - a common practice in wall paintings conservation - can allow to detect detachments of subsurface layers. Otherwise contact free (high tech) techniques like IRT have to be taken into account.

Superficial detachments of a few mm to cm in thickness or depth can be detected by the resonance method. The lighter the instrument used the thinner the detached parts detected are. Deeper subsurface defects can be detected with very thick or big metal instruments such as hammers; their use is however often not advisable at Cultural

Heritage objects. But even using such big instruments to our experience detachments over about 5 cm deep can normally not be detected.

For obvious reasons the test can only difficultly be performed in a noisy environment, which has to be taken into account, when planning the site investigation.

Further reading on resonance test

Drdácky and Lesák (2006) have extended the acoustic testing with logging the position and the signal. Lehrberger and Gillhuber (2007) demonstrated the telescopic stick which is now commercially available. Snethlage 2011 and Meinhardt et al. (2012) demonstrate the use for monitoring the weathering on natural stone.

2.3 Brush test

Aim of the test:

The test aims to quantify the intensity of granular disintegration of vertical or nearly vertical surfaces. The intensity of disintegration is on one hand compared between the different surfaces on one site. Moreover the result of surface consolidation is quantified.

Materials needed to perform this test:

- paint brush with soft short hair and flat end (e.g. stencil brush)
- Piece of cardboard board forming a frame around a square window of 10 cm by 10 cm
- flour shovel or similar recipient to collect the brushed off material
- scale to weigh the brushed off material or recipients to transport the brushed off material into the laboratory for weighing

Test procedure:

The cardboard board frame is held on a vertical or nearly vertical surface and the brush strikes 10 times in horizontal as well as 10 times in vertical direction. The detached material is collected in the flour shovel, then weighted and its amount is expressed in grams per square centimeter.

Caution / Mistakes to avoid:

It is clear that the test results can only be compared if always the same brush is used. But also the force used to strike over the surface must be kept as similar as possible.

The test results may vary as a function of relative humidity. Indeed, In very humid conditions the brush gets softer and stickier than under dry conditions and the surface may have different properties, especially when soluble salts are involved in the deterioration process leading to the detachment of surface material.

Further reading on brush test

Kircher and Zallmanzig (2011) have used the test on several materials and discuss the possibilities to calculate the depth of degradation of the tested surfaces.

Figure 3. Brush test, Görlitz, Heiliges Grab, Germany (photo Christoph Franzen).

2.4 Strip test

Aim of the test:

The goal of the test is to quantify the adherence of a usually thin surface layer to the supporting substrate.

Materials needed to perform this test:

- Tesa Power Strips® 2 x 5 cm
- Feather balance with stop scale and a clamp

Test procedure:

The adhesive strip is applied and evenly pressed to the surface to be tested. The balance is attached to the loose end of the power strip by the aid of the clamp. The power strip is stripped off vertically or parallel to the surface. The force used for this can be recorded on the balance and the material stuck on the power strip can be estimated visually and by weighing of the previously weighed clean power strip.

Caution / Mistakes to avoid:

If the test is performed outside the weather conditions play an important role, because in very humid or very cold conditions the sticky tape will adhere less to the surface than under dry and warm conditions.

If the surface carries biological material this is further influencing the measuring results.

Further reading on strip test

Littmann et al. (1999) have shown the application of the strip test on brick material. A standard 90 degree peel adhesion test derived from the ASTM standard D1876 - 08 (*Standard Test Method for Peel Resistance of Adhesives*) is often used in some conservation laboratories to assess the adhesion of glues. An adaptation of this test, also inspired from the ASTM standard D3359-08, has been proposed recently by Drdacky et al. (2011) to asses in the laboratory the cohesion and consolidation characteristics of historic stone surfaces.

Figure 4. Power Strip Test, Görlitz, Heiliges Grab, Germany (photo Christoph Franzen)

3 Conclusion

Simple field tests (SFTs) in the frame of stone conservation are based on little and easily available equipment and they look easy to perform. If some precautions are respected they can be reproduced in a satisfactory way. As all other measuring methods their successful application and interpretation needs some experience and in many cases a lot of back ground knowledge.

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References

Adamson, A. W. 1990. ‘Physical chemistry of surfaces’. 5th Ed., New York: John Wiley & Sons Inc.

ASTM D1876 - 08 Standard Test Method for Peel Resistance of Adhesives (T-Peel Test).

ASTM D3359 - 08 Standard Test Methods for Measuring Adhesion by Tape Test.

Bläuer Böhm, C., 2007. ‘Einige einfache Beobachtungen und Untersuchungen am Objekt‘. In Anja Diekamp Ed.: Naturwissenschaft und Denkmalpflege. Tagung 22., 23. März 2007, Innsbruck. Innsbruck University Press, 205-212.

Bläuer Böhm, C. 2005. ‚Auswirkungen von hydrophoben Fassadenmaterialien auf die Erhaltung und Pflegefähigkeit von Baudenkmälern. Beobachtungen aus der Praxis.‘In: Klimastabilisierung und bauphysikalische Konzepte (Ed. Exner, M., Jakobs D.), ICOMOS. Hefte des Deutschen Nationalkomitees XLII, Tagung Insel Reichenau 25.-27.11.2004, S. 117-128.

Brezesinski, G. and Mögel, H.-J. 1993. Grenzflächen und Kolloide. Physikalisch-chemischen Grundlagen. Spektrum Akademischer Verlag, Heidelberg, Berlin, Oxford.

Brugnara, M. Degaspieri, E. Della Volpe, C. Maniglio, D. Penati, A. Sibioni, S. Toniolo, L. Poli, T., Invernizzi S. and Castelvetro, V. 2004. ‚The Application of the Contact Angle in Monument Protection, New Materials and Methods.’ Colloids and Surfaces A: Physicochemical and Engineering Aspects, Volume 241, Issues 1-3, 14. July, 2004, Pages 299-312.

Carmeliet, J., Houvenaghel, J., Van Schijndel J. and Roels, S. 2002. Moisture Phenomena in Hydrophobic Porous Building Material, Part 1: Measurements and Physical Interpretations, in: Internationale Zeitschrift für Bauinstandsetzen und Baudenkmalpflege, 8. Jahrgang, Heft 2/3, p. 165-183.

Cather, S. 2003. Assessing causes and mechanisms of detrimental change to wall paintings. In: R. Gowing and A. Heritage (Eds), Conserving the painted past: developing approaches to wall painting conservation. Post-prints of a conference organised by English Heritage, London 2–4 December, London.

Charola, A. Elena, 2003. Water Repellents and other "Protective" Treatments: a Critical Review, in: Internationale Zeitschrift für Bauinstandsetzen und Baudenkmalpflege, 9. Jahrgang, Heft 1, S. 3-22.

DIN EN ISO 2409 (1994) Lacke und Anstrichstoffe - Gitterschnittprüfung. Ausgabe 1994-10.

D’Ham, G., Meinhardt, J., Niemeyer R. 2011. Bestimmung der kapillaren Wasseraufnahme nach Karsten und Mirowski, In: Auras, M., Meinhardt, J. and Snethlage, R. (eds), 2011. Leitfaden Naturstein-Monitoring. Fraunhofer IRB Verlag, Stuttgart. p. 82 – 92.

Drdácký, M.F., Lesák, J. 2006. Non-destructive diagnostics of shallow subsurface defects on masonry, in In-Situ Evaluation & non-destructive testing of historic wood and masonry structures - L.Binda, M.Drdácký and B.Kasal (eds.), ISBN 978-80-86246-36-9, NSF/MŠMT/RILEM, ITAM, Praha 2007, pp.140-147.

Drdácký, M., Lesak J., Rescic S., Slizkova S., Tiano P. and Valach J., 2011. Standardization of peeling tests for assessing the cohesion and consolidation characteristics of historic stone surfaces. Materials and structures, DOI 10.1617/s11527-011-9778-x

Ferreira, I., Pamplona, M., Simon, S., Lange, K. & Joao Melo, M., 2011. Assessment of conservation treatments with the contact sponge. Method on marble sculptures located in gardens. Conservation de la pierre dans les parcs, jardins et cimetières / Conservation of stone in Parks, Gardens and Cemeteries. 14ème journées d'étude de la SFIIC, Paris, 22-24 juin 201&, p.214-222.

Franzen, C., 2002. Historische Bauwerksteine in Südtirol. Verteilung und Verwitterungsverhalten. Dissertation, Leopold-Franzens-Universität Innsbruck.

Jeannette, D., 1997. Structures de porosité, mécanismes de transfert des solutions et principales altérations des roches des monuments. La pietra dei monumenti in ambiente fisico e culturale. Atti del 2° Corso Intensivo Europeo tenuto a Ravello e a Firenze dal 10 al 24 aprile 1994, 49-77.

Kirchner, K., Zalmanzig, J., 2011. Abriebversuch mit Pinsel; Bestimmung des Schälwiderstandes. In: Auras, M., Meinhardt, J. and Snethlage, R., 2011. Leitfaden Naturstein-Monitoring. Fraunhofer IRB Verlag, Stuttgart. p. 54-64.

Lehrberger, G., Gillhuber, S. 2007. Teplá-Trachyt : Herkunft, Verwendung, Verwitterung und Konservierung in der Klosteranlage von Teplá in Westböhmen; in: Gerhard Lehrberger Stephanie Gillhuber (eds) Endbericht zum "Modellvorhaben zur Beseitigung von Umweltschäden an vulkanischem Gestein des Klosters Teplá (Tschechien) im Braunkohle-Industriegebiet Egertal" DBU-Az 20725, Münchner geologische Hefte : Reihe B, Angewandte Geologie ; 22 Lehrstuhl für Ingenieur-Geologie, Techn. Univ. München, 2007. - 261 p.

Lisci, M., Monte, M. and Pacini, E. (2003): Lichens and higher plants on stone: a review. International Biodeterioration & Biodegradation, 51, 1-17.

Littmann, K., G. Pleyers, G., Bolz, C. 1999. Die Bestimmung der oberflächlichen Abwitterung durch den Power Strip Test. In: 5. Intern. Kolloquium Werkstoffwissenschaften und Bauinstandsetzen MSR ,99, TA Esslingen, pp. 537-548.

Meinhardt, J., Snethlage, R., Auras M. 2012. Natural Stone Monitoring - Investigation methods for a reliable evaluation of the effectiveness of conservation measures, this volume

ICOMOS (1964) International Charter for he conservation and restoration of monuments and sites (The Venice Charter -1964); http://www.icomos.org/; June 5th 2012

ICOMOS-ISCS, 2008/2010. Illustrated glossary on stone deterioration patterns / glossaire illustré sur les formes d'altération de la pierre / Illustriertes Glossar der Verwitterungsformen von Naturstein. ICOMOS Monuments and sites XV.; 21.8.2011

RILEM 25-PEM, 1980. Essais recommandés pour mesurer l'altération des pierres et évaluer l' efficacité des méthodes de traitement. Matériaux et Constructions 13, N. 75, 175-253.

Snethlage, R., 2011. Hohlstellendetektion mittels Resonanzklangfühler. In: Auras, M., Meinhardt, J. and Snethlage, R., 2011. Leitfaden Naturstein-Monitoring. Fraunhofer IRB Verlag, Stuttgart. p. 99-100.

Vandevoorde, D., Pamplona, M., Schalm, O., Vanhellemont, Y., Cnudde, V., Verhaeven E. 2009. Contact sponge method: Performance of a promising tool for measuring the initial water absorption, Journal of Cultural Heritage, Volume 10, Issue 1, Pages 41-47

Vergès-Belmin V., Anson-Cartwright, T., Bourguignon, E., Bromblet, P., Cassar J., Charola, E., DeWitte, E., Delgado-Rodriguez, J., Fassina, V., Fitzner, B., Fortier, L., Franzen, C., Garcia de Miguel, J.M., Hyslop, E., Klingspor-Rotstein, M., Kwiatkowski, D., Krumbein, W.E., Lefèvre, R.A., Maxwell, I., McMillan, A., Michoinova, D., Nishiura, T., Queisser, A., Pallot-Frossard, I., Scherrer, G.W., Simon, S., Snethlage, R., Tourneur, F., Van Hees, R., Varti-Matarangas, M., Warscheid, T., Winterhalter, K. Young, D. 2008. Illustrated glossary on stone deterioration patterns, ISBN: 978-2-918068-00-0, 78 p.

Wendler, E., Snethlage, R. 1987. Der Wassereindringprüfer nach Karsten – Anwendung und Interpretation der Messwerte; Bautenschutz + Bausanierung; Verlag Rudolf, Müller; 1989; Volume: 12; Issue: 6; p. 110–115