Heritage Problems, Causes and Solutions

Calogero Bellanca and Susana Mora Alonso-Muñoyerro

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In this volume have collaborated specially these architects:
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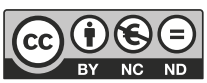

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In copertina | *Cover image*: *Colosseum*, detail. Photo by Susana Mora and Calogero Bellanca.

Dedicated to our parents

Maria and Antonino
Consuelo and Justo

Index

PART III – CONSTRUCTION APPLIED TO HERITAGE

CHAPTER 4. DAMAGE MAPS: MOISTURE PROBLEMS

DEFINITION

The survey of humidity, including that deriving from phenomena of rising by capillarity, is generally carried out with the direct method, following the perimeter of the infiltration and leaching zones. Special equipment is available on the market which, supported by the walls, allows us to determine their degree of humidity.

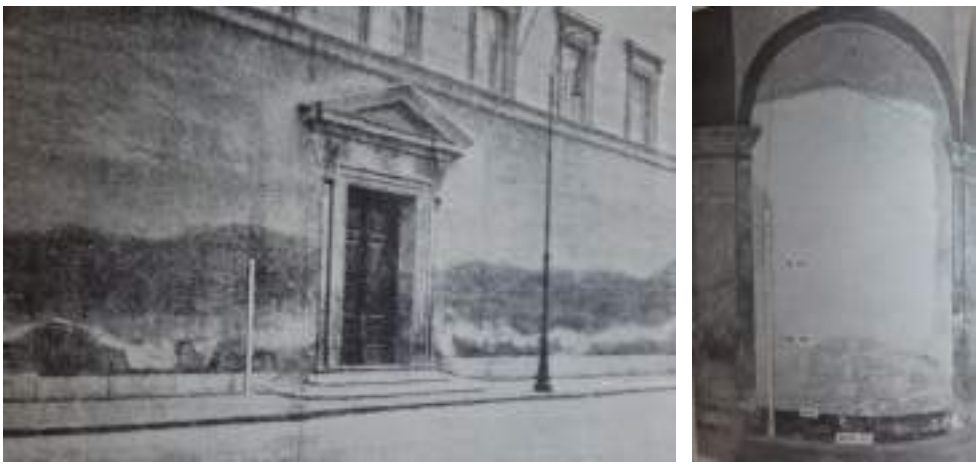


Fig. 1. From Giovanni e Ippolito Massari, *Risanamento igienico dei locali umidi*, Hoepli, Milano 1981, pp. 85-86.

It is essential that, before survey on site, we proceed to identify and perimeter the various areas where moisture is present and classify them depending on whether it is a capillary ascent, washout or infiltration.

The representation of humidity uses symbologies to highlight the different types, as can be seen in the chapter on the representation of the survey.

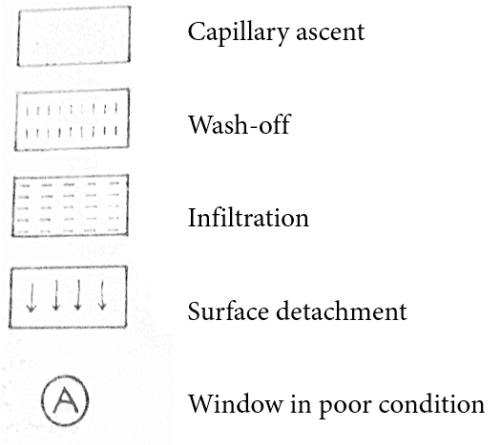


Fig. 2. Representation of Humidity Causes.

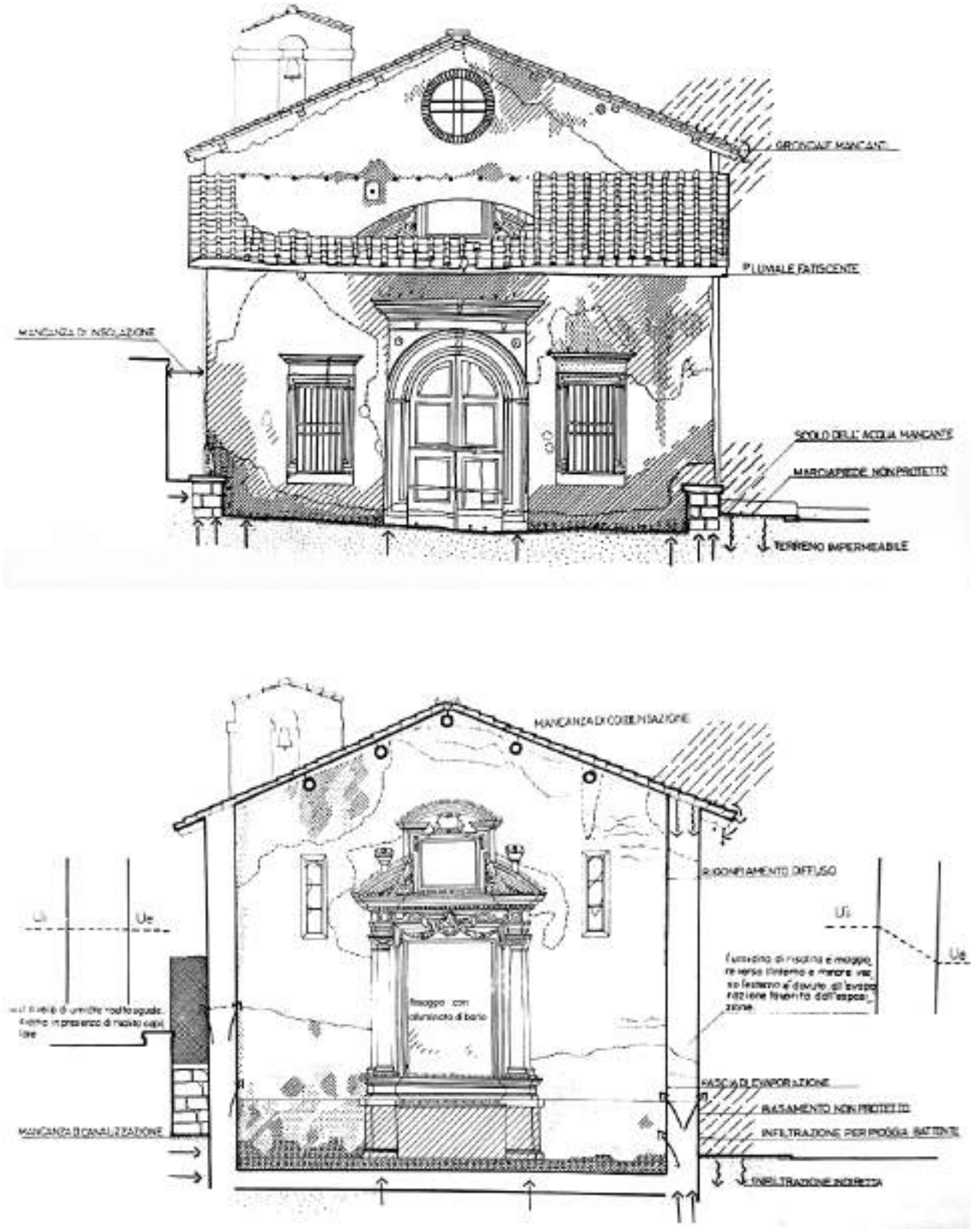


Fig. 3. Chiesa di San Salvatore a Tarquinia. From G. Carbonara, *Trattato di restauro architettonico*, vol. 2, Utet, Torino 1996, p. 571.

CAUSES OF DAMPNESS

1. Penetrating dampness (1)
2. Below ground moisture – capillarity
3. Air moisture condensation
4. Interstitial condensation
5. Superficial condensation
6. Internal plumbing leaks – accidental dampness

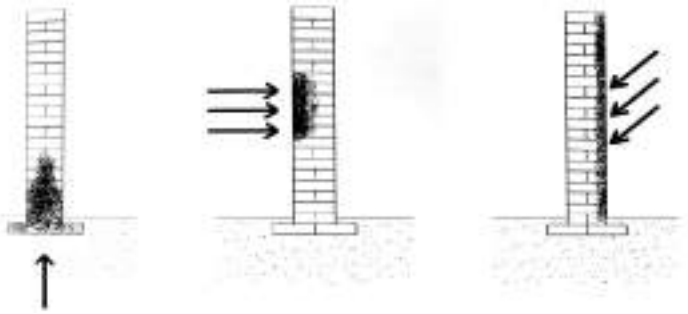


Fig. 4. From Rosa Agliata, Luigi Mollo, CNT-APPS Research Project, p. 53.

1. PENETRATING DAMPNESS

This is the result of the penetration of water from the outside into the enclosure due to rain. The water penetrates the interior or simply fills the surface pores without deepening the element, depending on the porous structure of the material, the water pressure and whether it is combined with wind. Therefore, these humidities can be both internal and external. In general, water can gain access through its porous structure, preferably by holes greater than 0.5 mm. By the presence of cracks or fissures (of capillary constitution), constructive joints, or if the gaps between bricks are not completely filled with mortar due to poor execution of the wall.

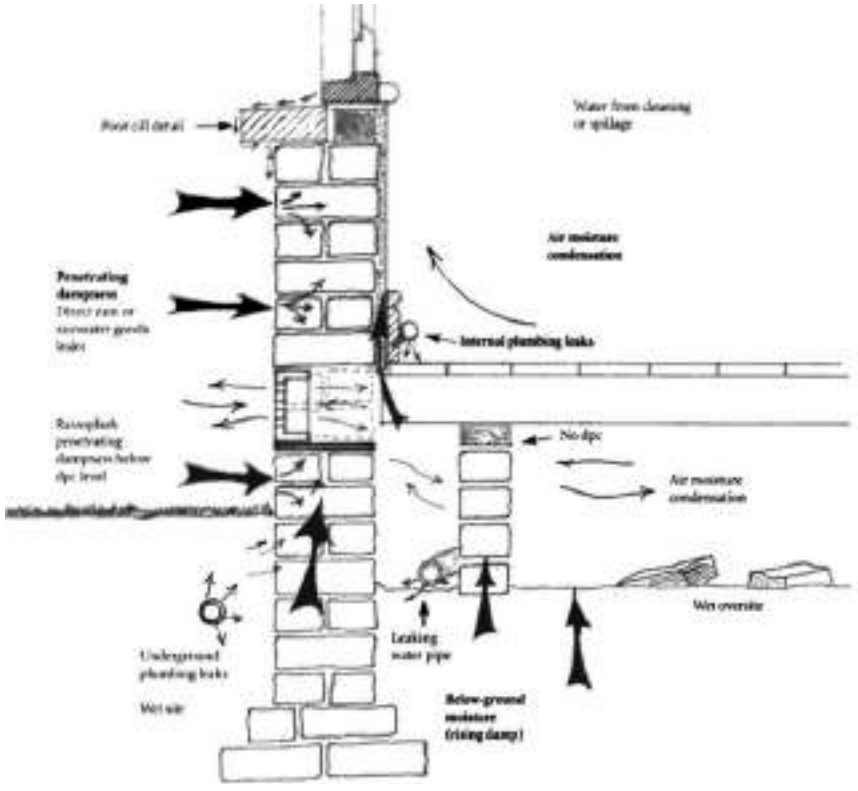


Fig. 5. From Luisella Gelsomino (a cura), *Recupero edilizio 6. Umidità, Tecniche e prodotti per il risanamento*, Alinea Editrice, Bologna 1988, p. 16.

2. BELOW GROUND MOISTURE – CAPILLARITY

When we introduce a tube into water we see how the latter rises. This is because the force of cohesion between their molecules is less than the adhesion of the liquid with the material through which it rises. The water will continue to rise until the surface tension with the tube balances with its weight.

In building, this phenomenon causes water to rise through the pores of the materials that are in contact with the ground.

These humidities can appear because the height of the water table has varied and now the foundation is in contact with the water, or because of the accumulation of water at this point because the slope of pavements or screeds is nonexistent, insufficient or has been deformed, among other causes.

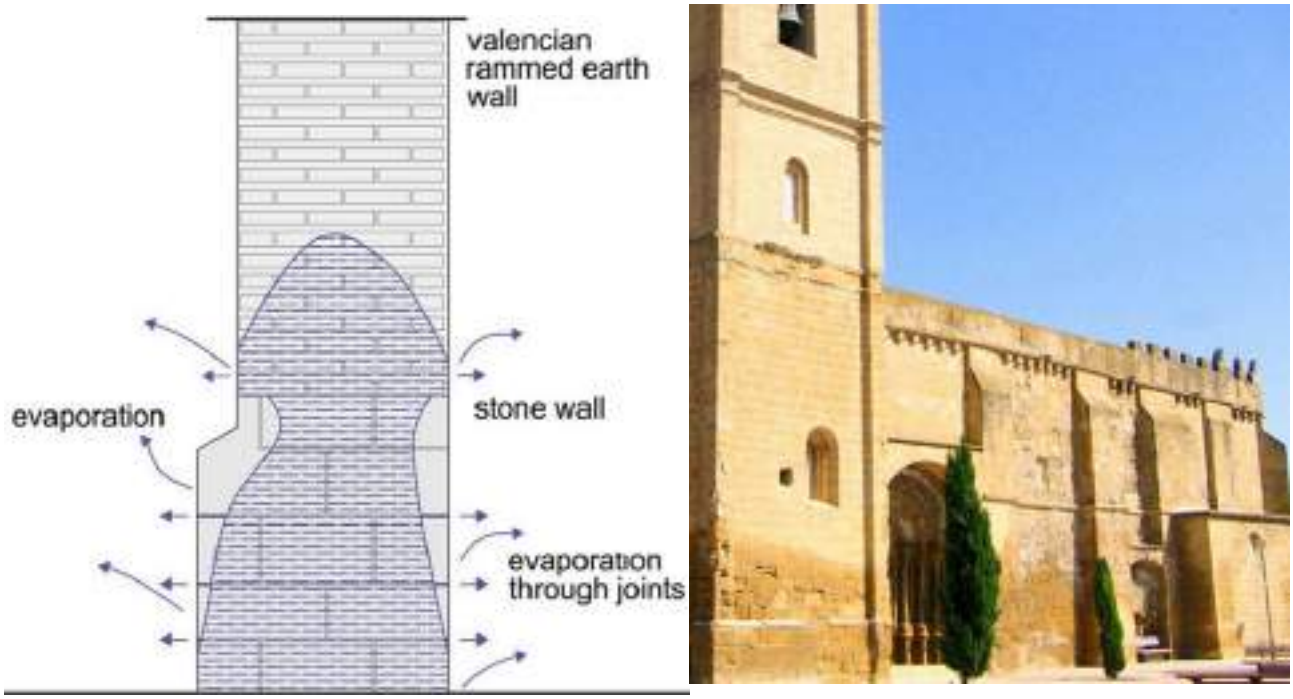


Fig. 6. From DCTA-UPM, *Tratado de rehabilitación*, Munilla-Lería, Madrid 1999, p. 98.

It can be identified because it is located at the base of the enclosure and follows a line more or less parallel to the ground. The height of this line will depend on the material and how the wall is coated.

- Why does it depend on the material? That the liquid rises to a greater or lesser extent is determined mainly by the diameter of the pore of the material of which it is composed. The smaller the radius, the higher the water rises on the element.

- Why does it depend on the coating? It will also depend on how easy it is to have access to the open air, which favors its evaporation. For example, in the case of exposed brick, the water that rises through the wall is able to evaporate earlier, due to its direct contact with the air, than if it were coated.

BELOW GROUND MOISTURE – EFFLORESCENCE

Sometimes the humidity is accompanied by white spots on the surface of the material. This is because the water drains salts from the lime of the foundation, mortar, brick, etc. and upon evaporation, the salts are deposited on the surface. The appropriate thing is to do an essay to know what type of salts are present to give an adequate treatment.
When the crystallization of the salts takes place inside the enclosure, the increase in volume that this phenomenon entails produces the breakage of the material. This phenomenon is called crypto-florescence. [1]

Fig. 7. From DCTA-UPM, *Tratado de rehabilitación,* Munilla-Lería, Madrid 1999, p. 101.

3. AIR MOISTURE CONDENSATION

The humidity of condensation occurs because at a certain moment the enclosure of an enclosure is saturated with water vapor until it reaches the point of condensation, or which the water vapor turns into liquid water. It is usually due to a drop in temperatures.
The vapor will go through the different materials that normally make up the facade and will lose pressure to the outside, but in turn the temperatures will decrease. It may happen that during this process the temperature reaches the dew temperature.
Depending on the point of the path where that temperature is reached, we can distinguish between two types of condensation: superficial and interstitial.

Fig. 8. From DCTA-UPM, *Tratado de rehabilitación*, Munilla-Lería, Madrid 1999, p. 102.

- Surface condensation: it will be characterized because inside the enclosure there will be a high humidity and may be associated with the appearance of fungi. This excess may be caused by the high production of steam in the premises and as a consequence of poor thermal insulation.

- Interstitial condensation: that which, as we have seen, is inside the wall. The manifestation of this type of humidity will be stains on the outside, possibly accompanied by efflorescence, fungus, detachments.

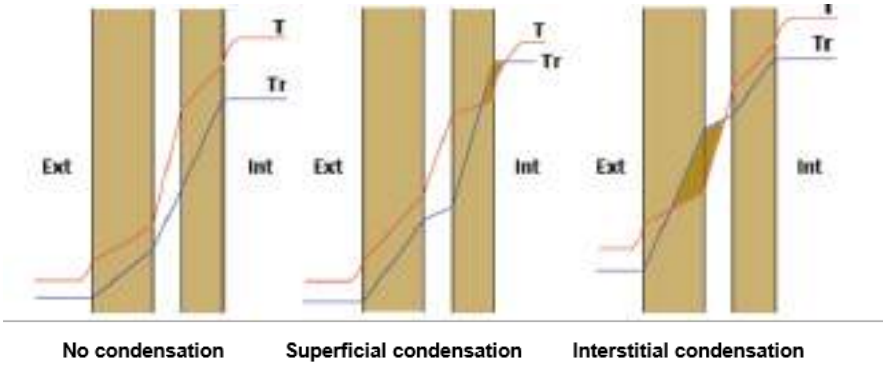


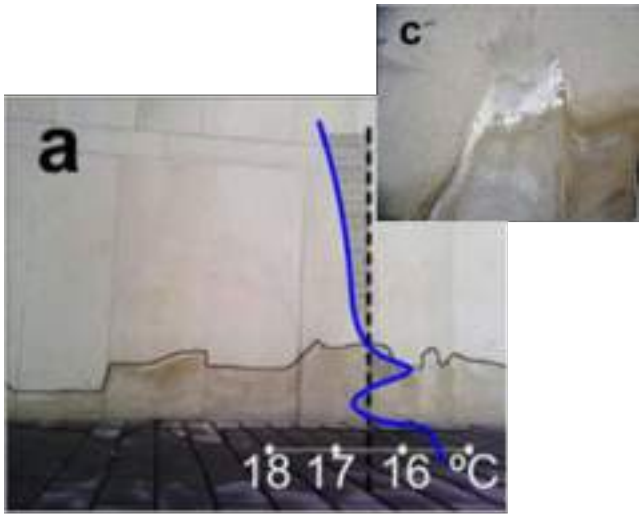
Fig. 9. From DCTA-UPM, *Tratado de rehabilitación*, Munilla-Lería, Madrid 1999, p. 103.

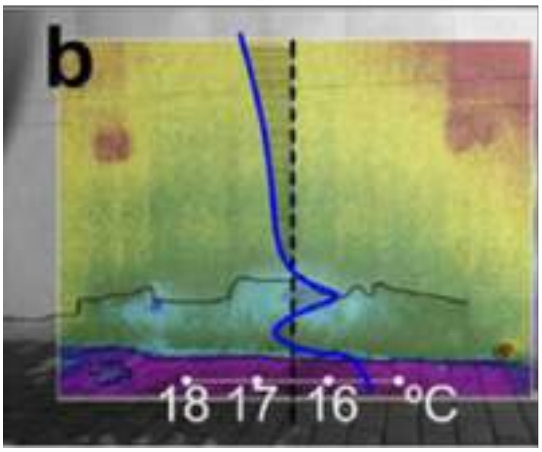
4. ACCIDENTAL

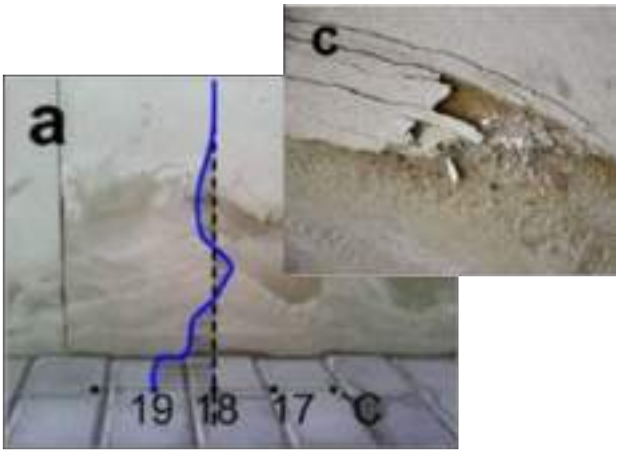
Fig. 10. From DCTA-UPM, *Tratado de rehabilitación*, Munilla-Lería, Madrid 1999, p. 105.

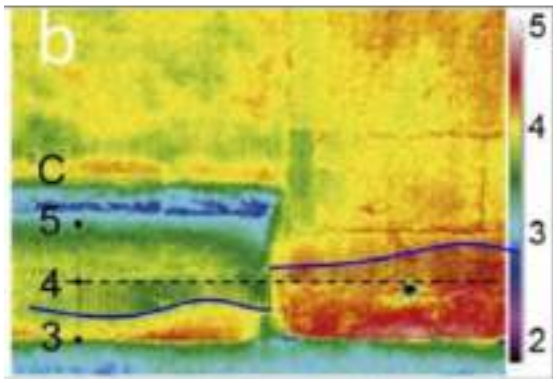
THERMOGRAPHY AND MOISTURE

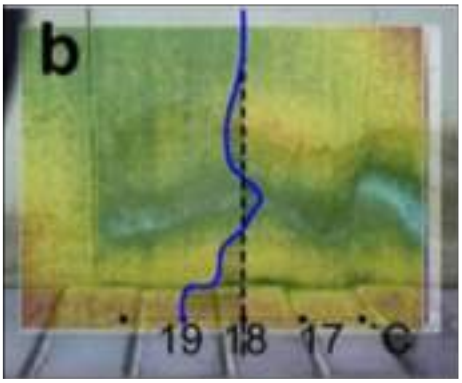
The use of thermovision chambers makes it possible to carry out a very precise mapping of humidity, by detecting temperature differences in the masonry with this method; by detecting the different temperatures of the humid zones, it is also possible to ascertain the direction of the infiltration, especially in the case of capillary ascent. Moisture survey is usually performed by taking into account that the imaging shutters must be between 1:50 and 1:10. (2)











NOTES

For the thematics relative to the study of Moisture problems, the dampness, we have a long history in many different countries. It is important don't forget… we can see: KNAPEN M. A., *Le problème de la conservation des matériaux, des habitations et des monuments*, "Revue des Entrepreneurs de maconnerie Ciments et beton Armé", Paris, avril-decembre 1925;

MASSARI G., TALENTI M., *Soleggiamento ed umidità dei muri*, In "Annali d'Igiene", 2, gennaio-febbraio 1946; Commissione di studio per l'umidità delle murature, Consiglio Nazionale delle Ricerche, attività svolta nell'anno 1963-64 in La Ricerca Scientifica" vol. IV, 2, Roma maggio 1965, pp. 83-86; MAMILLIAN M., *Le Mouvement de L'eau dans les mur*, "Annales de L'Institut Technique du Batiments et des Travaux Publics", 217, janvier 1966, p. 132. PHILIPPOT P., MORA P., *Technique et conservation des peintures murales,* Reunion mixte de Washington et New York 1965, 17-25 september, PLENDERLEITH H. J. *La conservation des antiquités et des oeuvres d'art*, traduit de l'anglais par Philippot P., Paris 1966. See also ICOMOS, Palais de Chaillot, *Paris Actes du Congres International sur L'umidité des Monuments*, Roma 1967.

1) MASSARI G., *L'umidità nei Monumenti*, Roma 1969, english editions 1971, ID, *Batiments Humides et insalubres, pratique de lur assainissement*, Eyrolles Paris 1971, CIGNI G., *Murature degradate dall'umidità e dall'inquinamento ambientale, protezione e interventi di risanamento*, Roma 1977; MASSARI G.I., *Risanamento Igienico dei Locali umidi,* Milano 1981, and subsequent editions, See also ICR, *Fattori di deterioramento, corso sulla manutenzione dei dipinti murali, mosaici, stucchi*, DIMOS II, Roma 1979; see also MORA P., *Causes of Deteriorations of Mural Paintings*, Roma 1974;

2) To study the causes of dampness and its solutions: AA.VV., a cura di GELSOMINO L., *Recupero Edilizio 6, Umidità, tecniche e prodotti per il risanamento*, Firenze 1988, ROMANELLI F., *L'origine dell'Umidità nella Basilica di San Vitale a Roma*, Roma 2001.

* In Spain, and in other countries, many pubblication in this field uses the definition of Rehabilitation, instead of Restoration.

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BURKINSHAW R., PARRETT M.J., *Diagnosis Damp*, AICS Books, Coventry (UK) 2004.

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ROCA P., LOURENZO P.B., GAETANI A., *Vaulted, Structures in history and modern structural solutions,* in *Historic Construction and Conservation. Materials, Systems and Damage,* Routledge, New York 2019, pp. 137-200.

CHAPTER 5. DAMAGE TESTS ON MASONRY CONSTRUCTIONS AND SURVEY, MAPS AND TESTS ON WOODEN CONSTRUCTION

INTRODUCTION: THE NECESSITY OF UNDERTAKING TESTS

Following an accurate structural survey and an in-depth and critical historical analysis, it is possible to identify possible extensions, tampering, raised areas, closures and openings in rooms, hidden cavities, shallow or deep lesions, further manifestations of static instability (detachment, rotations, subsidence, sinking, etc.), presence of humidity.

The above cannot always be detected through a simple direct visual examination of the monument by reconstructing the damage or deficiency inside the structures or hidden by the presence of plaster; on the other hand, this type of approach does not always allow to establish with certainty the cause generating the specific phenomenon or the static instability found. As far as the historical-archival analysis is concerned, the limitation may lie in the partial or total lack of documentation, as well as in the difficulties that lie in the temporal reconstruction of the successive construction phases and sometimes overlapping over the centuries. (1)

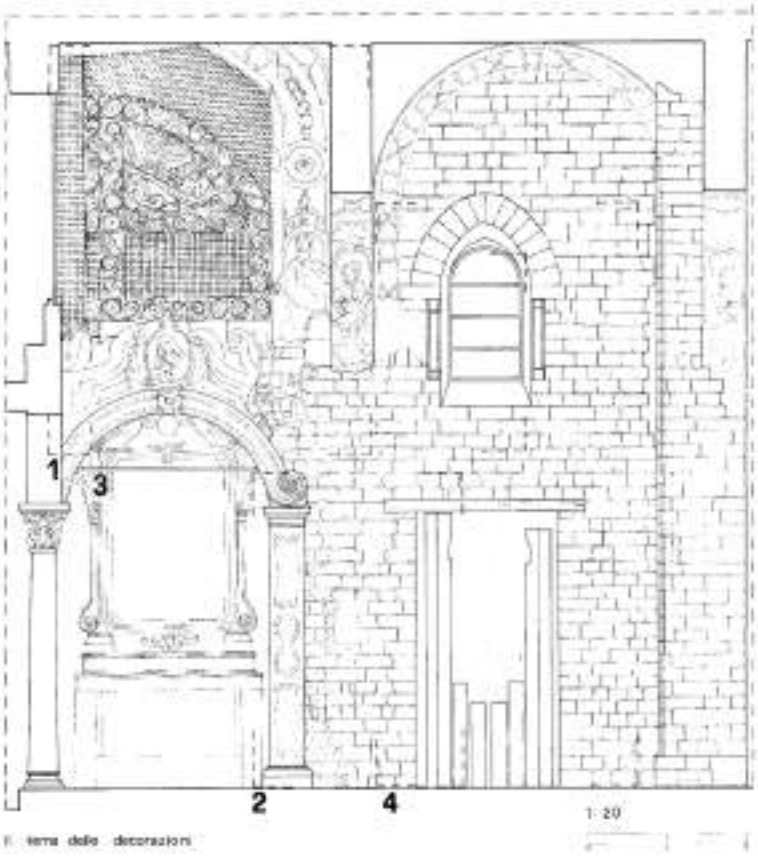

Fig. 1. Church of Santa Maria dell'Ammiraglio 1987. From C. Bellanca (a cura), *Una didattica per il restauro*, Atena Editrice, Roma 2008, p. 60.

STARTING POINT

The starting-point for the planning of the test are the material and mechanical survey and the maps of damage, including the different damage causes (deterioration, mechanical lesions and humidity problems).